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ABSTRACT

This hearing focused on H. R. 656, companion bill of S. 272, which calls for high performance computing legislation. This is one of several initiatives to provide for a coordinated federal research program to ensure continued U.S. leadership in high performance computing. The bill authorizes the development of a National Research and Education Network, development of new classes of supercomputers, development of the software needed to exploit the capabilities of supercomputers, and research and development centers in computer and computational sciences. This transcript of the hearing includes testimony and statements from 11 witnesses: (1) U.S. Senator Al Gore (Tennessee); (2) D. Allan Bromley, Science Advisor to the President and Director of OSTP (Office of Science and Technology Policy); (3) Kenneth M. King, EDUCOM; (4) Glenn Ricart, Suranet; (5) Jim Young, Bell Atlantic; (6) George L. Johnston, the Plasma Fusion Center of the Massachusetts Institute of Technology; (7) Stewart D. Personick, Bell Communications Research, Inc.; (8) Paul Young, University of Washington and Computing Research Association; (9) Gregory J. McRae, Carnegie Mellon University; (10) James E. Rottsolk, Tera Computer Co.; and (11) Lawrence A. Lee, the North Carolina Supercomputing Center. Also included are additional materials submitted for the record from the Association of Research Libraries, the American Library Association, ADAPSO (the computer software and services association), the Convex Computer Corporation, and the GAO (General Accounting Office). Deliberations on and suggested changes to the bill from the Subcommittee on Technology and Competitiveness Markup, the Subcommittee on Science Markup, and the Committee on Science, Space, and Technology Markup conclude the report. (DB)

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H.R. 656—THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

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HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE

AND THE

SUBCOMMITTEE ON
TECHNOLOGY AND COMPETITIVENESS

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

MARCH 7, 1991

[No. 13]

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*Ranking Republican Member.

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H.R. 656—THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

THURSDAY, MARCH 7, 1991

U.S. House of Representatives,
Committee on Science, Space, and Technology, Subcommittee on Science; and Subcommittee on Technology and Competitiveness,
Washington, D.C.

The subcommittees met, pursuant to notice, at 9:37 a.m., in Room 2318, Rayburn House Office Building, Hon. Rick C. Boucher [chairman of the Subcommittee on Science] presiding.

Mr. Boucher. This joint meeting of the Subcommittee on Science and the Subcommittee on Technology and Competitiveness will come to order.

Today we receive testimony on H.R. 656, authored by the chairman of our full committee, Representative Brown, which embodies the high-performance computing initiative long advocated by Representative Brown, and by Senator Al Gore of Tennessee, from whom we will be pleased to hear this morning.

It's also satisfying to note the strong support of the Administration for this effort, and we welcome as another of our witnesses Dr. Allan Bromley, the President's science advisor, who will elaborate on the Administration's position.

High-performance computing, which comprises large capacity data networks and supercomputers and the software to exploit the capabilities of both, is evolving into a powerful engine of scientific and technological progress. Ever more capable networks connect scientists and engineers with one another and with special research facilities and data bases. The future points toward information superhighways with applications for commerce, education, and research, limited only by our imaginations. Supercomputers play an increasingly prominent role in science and engineering research. In some research fields, they are auxiliary aids; in others, they are the only means through which progress can occur.

The opportunity now exists to accelerate development of all aspects of high-performance computing so that we can successfully confront the most difficult problems that currently serve as barriers to scientific and technological progress and to the future wellbeing of society. These problems often are referred to as "grand challenges" and include the modeling of climate to assess the consequences of human activities on the environment, detailed analysis of the structure of materials to allow development of better high-temperature superconductors, better understanding of turbulent combustion processes that would lead to highly fuel efficient and less polluting vehicles, and determination of the function of biologically important molecules to unlock the secrets of cell biology and thereby make enormous strides in the cure of disease.

Our witnesses today will comment on the proposal to develop and implement a national high-performance computing program that will build on existing R&D activities of the Federal Government to achieve orders of magnitude improvements in network capacity and computing performance. The bill calls for an interagency initiative that places responsibility for planning and coordinating with the White House Office of Science and Technology Policy. The principal agencies contributing to the initiative—the National Science Foundation, the Defense Advanced Research Projects Agency, the Department of Energy, and the National Aeronautics and Space Administration—are all represented here this morning.

The bill authorizes the development of a multi-gigabit National Research and Education Network, development of new classes of supercomputers, development of the software that is needed to fully exploit the capabilities of the most powerful computers, and the vigorous basic research and education program in computer and computational sciences. The four components of the high-performance computing program will help consolidate and focus research and development activities so as to capitalize on our lead over international competitors in some areas and accelerate developments in other areas where the competition is tighter.

This morning we are seeking the views of a broad range of witnesses on the specific provisions of H.R. 656. We hope to discover how the bill might be improved to help us achieve its legislative objectives. We will welcome each of our witnesses and look forward to their presentations.

It's now my privilege to recognize the co-chairman for this hearing, the chairman of this committee's Subcommittee on Technology and Competitiveness, the gentleman from North Carolina, Mr. Valentine.

[The prepared opening statement of Mr. Boucher follows:]

OPENING STATEMENT
ON THE
HIGH-PERFORMANCE COMPUTING ACT OF 1991
H.R. 656
BY THE
HON. RICK BOUCHER (D-VA)
CHAIRMAN
SUBCOMMITTEE ON SCIENCE

March 7, 1991

This joint meeting of the Subcommittee on Science and the Subcommittee on Technology and Competitiveness will come to order. Today we receive testimony on H.R.656, authored by the Chairman of the Full Committee, which embodies the high-performance computing initiative long advocated by Rep. Brown and by Sen. Gore of Tennessee, from whom we will be pleased to hear this morning. It is also satisfying to note the strong support of the Administration for this effort, and we welcome as a witness Dr. Alan Bromley, the President's Science Advisor, who will elaborate on the Administration's position.

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These problems are often called Grand Challenges and include: modeling of climate to assess the consequences of human activities on the environment; detailed analysis of the structure of materials, to allow development of better high-temperature superconductors; better understanding of turbulent combustion processes, which would lead to highly fuel efficient and less polluting vehicles; and determination of the function of biologically important molecules to unlock the secrets of cell biology and thereby make enormous strides in the cure of disease.

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This morning we are seeking views from a range of witnesses on the specific provisions of H.R. 656. We hope to discover how the bill might be improved to help ensure that the goals of the legislation are achieved.

We welcome each of our witnesses and look forward to your testimony.

Mr. **Valentine**. Thank you very much, Mr. Chairman.

I am extremely pleased to have the opportunity to chair jointly with Mr. Boucher this hearing on high-performance computing, and I will make these opening remarks very brief.

Over the past few years, there have been tremendous advances in computer hardware, networking, and computational technology. These advances have resulted in an exponential increase in scientific communications and computing that has had a positive impact on the way universities and industry and Government interact in research.

These interactions have encouraged interdisciplinary research that is necessary to solve the extremely difficult scientific problems facing our country today. However, we must continue to move forward in the area of high-performance computing. Advances in interactive communications could provide a virtual proximity for conducting meetings, workshops, and educational activities. Time and money could be saved in the way we conduct our business, and resources could be shared across multiple institutions to enhance the capabilities of those who are at the low end of the scale.

Cooperative efforts must be encouraged and supported to explore and exploit parallel computing. Both hardware and software technology advances are needed to process and access the tremendous data bases that will be generated in projects like the human genome research and Mission to Planet Earth.

There are many other areas that I could talk about, but for the sake of brevity, I shall not. Let me conclude by saying that America must maintain its leadership in high- performance computing, and high-performance computing enhances basic scientific research and the transfer of this research into technologies and products that support our competitiveness in the global marketplace.

I'm encouraged that the President has proposed a high- performance computing and communications program. I am pleased that there is legislation in the Senate introduced by Senator Gore similar to H.R. 656. I look forward to hearing the testimony of Senator Gore and Dr. Bromley and the other distinguished witnesses. I'd like to especially welcome Mr. Larry Lee, the Director of the North Carolina Supercomputer Center, which is in our district.

I look forward to working with Mr. Boucher and other members of the Science Committee in the passage of this legislation, and I yield back the balance of my time.

Mr. **Boucher**. The Chair thanks the gentleman and now recognizes the ranking minority member of the Science Subcommittee, the gentleman from California, Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman.

Welcome, Senator Gore. We appreciate you being here and certainly are looking forward to your testimony regarding the bill that you've introduced as S. 272, and its companion bill H.R. 656.

I would like also to welcome Dr. Bromley, whom we've heard before this committee, our science advisor to the President and the Director of the Office of Science and Technology Policy.

High-performance computing and computer communication networks are becoming increasingly important to the advancement of scientific research and economic competition. This act has the potential to extend U.S. technology leadership in high-performance computing. It will also spur U.S. productivity and international competitiveness and enhance the Nation's educational infrastructure.

The United States currently reigns as the world leader in high-performance computing; however, aggressive steps must be taken to maintain that dominant position. Certainly, Japan and Europe are both rapidly gaining ground on the international race for superiority in high-performance computing. This interagency initiative will work to ensure America's preeminence in this technology.

At this point, one of my major concerns is the extent of the Federal Government's involvement in developing the National Research and Education Network. I look forward to testimony which will clarify the exact role of the Federal Government.

Future goals for the initiative include developing the hardware and the software to such a level that the so-called "grand challenge" problems can be tackled. Key to solving these grand challenges will be utilizing—or rather the utilization of—the five NSF supercomputer centers, of which the San Diego Supercomputer Center, located at the University of California at San Diego, is a shining example. This center provides access to leading edge supercomputing and visualization, extensive application software, and comprehensive user service. I fully anticipate that the San Diego Supercomputer Center will play a vital role in this initiative.

I will conclude my statement at that point, but certainly look forward to the testimony of all of the witnesses, and I want to thank the chairmen of both of the subcommittees for this joint hearing.

Mr. **BOUCHER**. The Chair thanks the gentleman and recognizes Mr. Lewis from Florida, the ranking minority member of the Subcommittee on Technology and Competitiveness.

Mr. **LEWIS**. Thank you, Mr. Chairman, and thank you, my chairman, for holding this hearing, and thank you for coming over, Senator Gore, and discussing the merits of your bill.

Few areas in the United States' technology are recognized as having been developed here first and in which we are still the world's leader as the area of high-performance computing. The benefits of this U.S. position have been taken to make contributions both to our economy and to our advances in other fields of technology. The question is: how can we maintain our status as number one in the world?

Before us are two initiatives. One is the high- performance computing legislation, H.R. 656, and the second one is the Administration's high-performance computer initiative. Which is best? Maybe neither but a combination of both. I look forward to today's testimony, and we have a sterling list of witnesses who are going to help us make those decisions.

Thank you, Mr. Chairman.

Mr. **BOUCHER**. The Chair thanks the gentleman and is now pleased to recognize the chairman of the full Committee on Science, Space, and Technology and the author of H.R. 656, the gentleman from California, Mr. Brown.

Mr. **BROWN**. Thank you, Mr. Chairman.

Last night the President, in a moving and excellent speech, indicated that our highest priority in this post-Gulf war period was to restore America's economic leadership, and he challenged us to pass enabling legislation to do that and accomplish other high priority items within 100 days. I think we ought to accept that challenge. This is a crucial item in restoring America's competitive leadership in the world.

This committee has for many years had on a bipartisan basis a strong interest in this kind of legislation, exemplified by the leadership of Mr. Boehlert and others on the minority side as well as those on the majority side. I would like to have this committee accept as a goal to move this legislation, and I hope Senator Gore can make the same commitment in the Senate within that 100-day period and get this effort to restore America's economic leadership off to a good start, and I very much appreciate the contribution of the witnesses here this morning in helping us do that.

Thank you.

Mr. BOUCHER. The Chair thanks the gentleman and recognizes the gentleman from Maryland, Mr. Gilchrest.

Mr. GILCHREST. Thank you, Mr. Chairman.

They say this is the information age, and I come before this hearing to listen to the witnesses as someone who knows very little about computers—even home computers—so I will be, I'm sure, fascinated with the testimony, and I look forward to it.

We hear a great deal about infrastructure. I think probably the most—in my judgment, anyway—important infrastructure in the United States and probably the world is education, and the way education is successfully completed or is successful is through the continuing flow of information. So if we can provide this flow of information to our public schools, our research facilities in a networking fashion to enhance the quality of life for people through our constant improvement of competitiveness with the rest of the world, then we will have completed our task, and we can turn it over to the next generation to improve upon it some more.

So I look forward to the testimony this morning.

Mr. BOUCHER. The Chair thanks the gentleman and recognizes the gentlewoman from Missouri, Mrs. Horn.

Ms. HORN. Thank you, Mr. Chair.

I have no opening statement. I do look forward to listening to our illustrious guests. Thank you.

Mr. BOUCHER. The gentleman from Florida, Mr. Bacchus.

Mr. BACCHUS. Thank you, Mr. Chair.

I'd just like to say a personal word of welcome to Senator Gore. His family and mine hail from the same part of the back woods in Tennessee. My grandmother has been voting for people named Gore for about half a century. I was born in Nashville and went to Vanderbilt, as he did, and Senator Gore's father was one of my professors during my senior year at Vandy after I worked in his last campaign as a volunteer.

One of the reasons I came to Congress was to work with people like Al Gore. I'm very glad especially that he has taken the time so often to come over to our side. I think that's one of the reasons he's done so well on the other side is that he has learned from us as well.

I'm a very strong supporter of this legislation, and again, sir, welcome.

Mr. BOUCHER. The gentleman from Michigan, Mr. Henry.

Mr. **Henry**. Well, thank you, Mr. Chairman.

I don't have an opening statement, but I do have an issue I would like to be raised in my absence, since I have a markup which begins in another committee in about five minutes, and it picks up on a comment of Mr. Gilchrest's which I think is very central to part of this debate.

I wanted to acknowledge Chairman Brown's, Mr. Boehlert's, and Senator Gore's leadership on this. These are not sunshine patriots that jumped on an issue because it became popular; they're the people who made it popular by pushing the issue long before it was. I recognize their leadership on this and commend them for the fact that this is now central to the issue of the debate on America's technological competitiveness, the issue of technology development, technology transfer, technology adaptation, and competitiveness in the truest sense of the word. They're tough issues because they're vanguard issues.

Senator, I'm very genuine in expressing my appreciation for what you've done.

Part of that leadership reflected itself in fighting for and celebrating victories over the years in establishing the supercomputing centers through the National Science Foundation and the NSF net programs, which went on-line about three years ago. I just want to put on the agenda my concern that as we move forward on this new initiative we not lose sight of what is there in place and to keep that educational networking vital and strong.

And I mention it only because, to the best of my knowledge in a preliminary and rather rudimentary look at the budget, we have a Presidential initiative, which I commend — I think which we all commend—we're trying to shape and fine tune it, but it leaves the NSF net flat, and I think that has created some concern in the university community and some of the research community, and I just want to be sure we not lose sight of that component as we address the grander whole.

Thank you very much, Mr. Chairman. Please excuse my absence.

Mr. **Boucher**. The Chair thanks the gentleman and recognizes the gentleman from Illinois, Mr. Costello.

Mr. **Costello**. Mr. Chairman, I have an opening statement, but out of respect for Senator Gore's schedule, I would ask that it be entered into the record at this time.

Mr. **Boucher**. Without objection, it will be made a part of the record.

[The prepared opening statement of Mr. Costello follows:]

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SUBCOMMITTEE ON SCIENCE
HEARING ON THE HIGH PERFORMANCE COMPUTING ACT OF 1991
MARCH 6, 1991

Mr. Chairman, today we welcome Senator Al Gore and Dr. Bromley, as well as all our other distinguished guests, to discuss the High Performance Computing Act of 1991-H.R. 656.

As I stated last year, and still believe today, it is heartening to know that this is one technological arena in which we are still a world leader. However, Japan and Europe are investing funds into the improvement of their own high performance computer industry. The United States must maintain its edge, so that we do not find ourselves in a secondary position as we have in other strategic industries.

As we listen to our witnesses today, we will be able to explore options Congress has in order to meet the challenges and keep the advantage over our foreign competitors.

Mr. Chairman, I look forward to hearing the testimony and I thank you for calling this important hearing.

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Mr. **Boucher**. The Chair recognizes the gentleman from New Hampshire, Mr. Swett.

Mr. **Swett**. Thank you, Mr. Chair.

I just wanted to say that I have a meeting coming up that organizes the Economic Development Subcommittee on the Public Works and Transportation Committee so I won't be able to attend the hearing, but I appreciate the work that you're doing, Senator Gore, and I just wanted to add that my experience on the infrastructure issue from highways, bridges, and intermodal transportation is not unlike the kind of issues that we're dealing with here on this subcommittee, and I appreciate that work, I applaud it. My computer experience is extensive, and I understand the great power and wealth that can be derived from a better intermodal connection of our informational system.

I look forward to your testimony, and I look forward to success in this committee.

Thank you very much.

Mr. **Boucher**. The Chair thanks the gentleman and recognizes the gentleman from Arkansas, Mr. Thornton.

Mr. **Thornton**. Thank you, Mr. Chairman.

We have a rare moment of opportunity in this country with the events that have been transpiring over the past year and a half and this initiative by our own chairman, minority leader, minority representatives, and by my distinguished former colleague, great friend, and neighbor, Senator Gore.

It's a pleasure to welcome you. I'm looking forward to your testimony.

Mr. **Boucher**. The gentleman from Indiana, Mr. Roemer.

Mr. **Roemer**. Thank you, Mr. Chairman.

As Mr. Swett said, I, too, have an Education Subcommittee hearing to go to. In terms of brevity, I will just say that we're delighted to have you here. I've heard a lot about you, Senator Gore, being a freshman here, that you got your start on this committee. I'm anxious to work with you from the Senate side and with the chairman on this committee to forge a relationship for our new domestic agenda, combining education and technology—an opportunity that I have as a freshman on these two very exciting committees—and the exciting challenges we face as a country coming up into a new century, and I look forward to working with you.

Thank you.

[The prepared opening statements of Messers. Boehlert and Bruce follow:]

STATEMENT ON THE HIGH PERFORMANCE COMPUTING INITIATIVE

Every program that comes before this committee tries to cloak itself in the mantle of competitiveness. There are even those who tell us that sinking billions of taxpayers' dollars into building a fifty-four mile long tunnel in Waxahachie, Texas is going to move us to the top of the world economy.

These are the same people who keep promising us massive Japanese participation in the project. Well, that tunnel is going to leave one heck of a sandpile, and I wouldn't be surprised to see the Japanese come along and "participate" in the project by simply taking that sand and turning it into silicon for computer chips.

Just when I am ready to despair that we don't have a clue about what to invest in, along comes the High Performance Computing Initiative. This promises to actually deliver on its claim of keeping our nation at the forefront of new technologies and competitive in the global marketplace. I applaud the Bush Administration, especially Dr. Bromley, as well as Senator Gore and Congressman Brown, for their leadership on this issue.

Economists used to think in terms of labor versus capital intensive production. But we are witnessing a revolution in the way people work that renders that old dichotomy meaningless. Instead, all work is becoming knowledge and information intensive. Whether you tune engines, build construction equipment, sell groceries or write news stories, the way you work is being transformed by new information technologies.

The High Performance Computing Initiative promises to build on those communications and computing technologies to boost our nation's educators and students beyond our current capabilities into uncharted territory. It promises rich possibilities for new technologies, new research, new insights about our world, and I am a strong supporter of this effort.

OPENING REMARKS
THE HONORABLE TERRY L. BRUCE
SCIENCE SUBCOMMITTEE HEARING
MARCH 7, 1991

HIGH PERFORMANCE COMPUTING

THANK YOU, MR. CHAIRMAN. HIGH PERFORMANCE COMPUTING IS ONE OF THE CORNERSTONES OF THIS COUNTRY'S TECHNOLOGY BASE FOR THE FUTURE. THE FACT THAT THIS HEARING IS BEING CONDUCTED BY THE SCIENCE SUBCOMMITTEE AS WELL AS THE TECHNOLOGY AND COMPETITIVENESS SUBCOMMITTEE CONFIRMS TO ME THAT THE FUTURE OF HIGH PERFORMANCE COMPUTING IN THIS COUNTRY IS RELATED TO THE FUTURE OF THE UNITED STATES AS A GREAT SCIENTIFIC AND TECHNOLOGICAL POWER.

AT THE UNIVERSITY OF ILLINOIS AT CHAMPAIGN-URBANA, THE HIGH PERFORMANCE COMPUTING ACT, INTRODUCED BY OUR FULL COMMITTEE CHAIRMAN, MR. BROWN, IS BEING GIVEN GREAT PRAISES. THE NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS IS AT THE UNIVERSITY OF ILLINOIS, AND I HAVE VISITED THAT SITE MANY TIMES. I HAVE SEEN THE GREAT THINGS THAT SUPERCOMPUTING CAN DO, BUT I AM ALSO AWARE OF EVERYTHING THAT STILL NEEDS TO BE DONE.

THE HIGH PERFORMANCE COMPUTING ACT CAN HELP THE INDUSTRY ESTABLISH ITS LONG-TERM GOALS. THESE SUBCOMMITTEES NEED TO ACT QUICKLY AND POSITIVELY TO PUSH THIS PIECE OF LEGISLATION IN THE RIGHT DIRECTION. AS AN ORIGINAL COSPONSOR OF THIS LEGISLATION, I AM WILLING TO DO WHAT I CAN BE ENSURE THAT THIS HAPPENS: FOR THE SUPERCOMPUTING CENTER IN MY DISTRICT AND FOR THE FUTURE OF THIS COUNTRY.

I LOOK FORWARD TO HEARING THE TESTIMONY OF OUR WITNESSES TO HEAR THEIR VIEWS ON THIS CRITICAL AND TIMELY LEGISLATION. AT A

TIME WHEN THE UNITED STATES IS REJOICING AT THE CONFIRMATION OF THE GREATNESS OF ITS MILITARY POWER, EMPHASIS SHOULD BE PLACED ON SO-CALLED DOMESTIC ISSUES, SUCH AS HIGH PERFORMANCE COMPUTING SO THAT OUR EXCELLENCE IN ALL AREAS CAN BE MAINTAINED.

THANK YOU.

Mr. BOUCHER. The Chair thanks the gentleman.

It is a particular pleasure this morning to welcome our first witness, Senator Al Gore from Tennessee, who has long been the leading advocate in the Congress for the development of a high-performance computing and networking program.

Senator Gore, we congratulate you on the success that you have had in bringing the initiative to this point, and we note with satisfaction the strong support now offered by the Administration for that initiative.

So with those comments, it is a pleasure to welcome you this morning, and we'll be very pleased to receive your testimony.

STATEMENT OF HON. AL GORE, A UNITED STATES SENATOR FROM THE STATE OF TENNESSEE

Senator GORE. Thank you very much, Mr. Chairman.

As a neighbor, I'm especially grateful to you for your courtesy in inviting me this morning, and, Congressman Valentine, thank you for co-chairing this hearing and for your friendship as well.

We worked recently on the Carnegie Commission Panel on Science in the Congress together, and Congressman Boucher and I have worked on a number of initiatives together over the years, and I have previously come to express my heartfelt joy that Congressman Brown is chairman of this committee now. You may get tired of hearing that, but we're really excited at the dynamism and leadership that is already evident here.

May I express my thanks to Mr. Packard and Mr. Lewis for convening this hearing as well and to Congressman Sherwood Boehlert and to all members of the committee. I appreciate your invitation to be here.

As a former member of this committee, I note with pride that this whole endeavor that we're discussing here today began about 12 years ago in this very committee room. As a new member of this committee, I began exploring the areas of computational science, what the implications were for our country, what our Nation's capacity was to make good use of computers and how we might deal with the information revolution, and in that connection I would like to thank the staff of this committee on both sides, the present staff and their predecessors, for the help that I have had over the years, and I include Dave Clement in this. I don't see him here today, but it has been a bipartisan working relationship from the very beginning, and I am grateful for that.

You have a great witness list today, Mr. Chairman, and I will ask your consent to put my full formal statement in the record and just talk about why I think this initiative is so important, and in the course of my remarks, I will attempt to briefly address some of the questions and inquiries that came out in the opening statements.

One other introductory comment. Several people here have already noted the key role played by Dr. Allan Bromley in bringing us to the point we're at here today. If I might add to those words briefly my own personal statement of what a joy it is to work with Dr. Bromley on an issue like this, it took very little time for him, after coming into the Administration, to take command of a whole series of issues. I've had my disagreements with him on a few of those issues, but I have strongly agreed with him on most of them, and this is one where we really see eye-to-eye, and there is very little difference between the Administration's plan and H.R. 656 and S. 272.

That's not by accident, incidentally. Several years ago, this committee and the Senate Commerce Committee, and then subsequently the House and Senate, passed legislation called the Supercomputer Network Study Act. It directed the Administration of then-President Reagan to conduct a full and extensive study of what should be done here. We made specific suggestions on the direction we thought it ought to move in.

Well, they undertook that study, and after several years they came back and said, "You know, we agree with you. This is something that ought to be done. This is in the best interest of our country." And we worked together with the Administration to develop the details of how this ought to proceed. It is not an accident that these plans are moving in parallel here in the House and in the Senate and in the Administration.

Of course, any Administration would like us to appropriate all the money we appropriate each year and never give any guidance as to exactly how it should be spent, but we take that with a grain of salt. The details of the plans are really in conformity, and that is partly due to Dr. Bromley's leadership and his powers of persuasion within the Administration. He used them, incidentally, in a hearing Tuesday on the Senate side, and we have very strong bipartisan support over there.

You know, I was thinking listening to your statements this morning about the celebration we all shared in last night, and I don't think it's stretching things too much to say that one of the principal reasons our military coalition was able to win such a decisive victory was that we had a superior command of information in all its forms. One of the media focuses of this war was the smart bomb and the technology that made it possible for those bombs to avoid civilian casualties and go right to the military targets, the information management involved in the massive logistics effort—the list of examples is virtually endless, and I'll not even start going through more of them, but the point is we had a superior command of information. Our ability to win the economic battles of the future with Japan and a unified Europe, for example, will also depend on whether or not we develop a superior command of information of the kind directly relevant to success in the world economy.

The word "infrastructure" has already been brought up here this morning. Let's think about that word because it represents an important focal point for national unity of purpose. Democrats and Republicans have arguments from time to time, especially about the role of Government in moving our country forward. One thing Democrats and Republicans, conservatives and liberals have always been able to agree on is that infrastructure, which empowers individuals and empowers companies and empowers the whole Nation to perform more efficiently and to reach toward more of our potential— infrastructure represents one of those tasks appropriately assigned to Government. It's one of the ways we can work together as a country through Government to build a brighter future for all of our citizens.

The future is arriving more quickly these days. It becomes a cliche to talk about how fast things are speeding up. Members of this committee know that better than members of any other committee in Congress. But still it sometimes leaves us behind, and in the debate about infrastructure, that's true, because even though we agree on infrastructure, we still think of it in terms of roads and bridges, deep water ports, railroad lines, and the like. But, Mr. Chairman, look at the dramatic success of some of these newly emerging countries in the world economy that have practically no natural resources, practically nothing to work with except the ingenuity of their people and their ability to use knowledge and information.

Clearly, we have to think of our national infrastructure in broader terms, newer terms, and define it in ways that include our ability to use information. We're now part of a global civilization. It has been prematurely heralded and announced several times in this century since the days of Woodrow Wilson, but now it is here, partly due to the electronic media that lets us sit in our living rooms and watch the bombs dropping in Baghdad, that lets people everywhere in the world hear music recorded in Nashville, Tennessee.

The world is being brought together, and this global civilization and this global marketplace is based on shared knowledge in the form of digital code. Digital code is now the lingua franca of global civilization, and those nations best able to use knowledge and information in the form of digital code will be those nations best positioned to better the lives of their people and compete successfully in this new global civilization. We have a lead in network technology, but it's generally assumed to be about 18 months over the Japanese, and if we sit on our lead, we'll lose it the way we have in some other critical areas.

I want to make it possible for a school child in Tennessee or Arkansas or Virginia or the other States represented here to come home after school and, instead of playing Nintendo, plug into the Library of Congress with a device that looks very much like a Nintendo machine and no more expensive. We know exactly how to do that today. All the technologies are available today. What's missing? The political imagination and willpower. It's present in this committee.

Now, we do have some problems. This information revolution has created fantastic new abilities to shape the world around us, to unlock the secrets of nature, and all the rest, but it has resulted in the accumulation of more data than we can possibly absorb. It's just stacking up unused. We don't take advantage of it. It reminds me of the way we used to approach agricultural policy. We had these huge silos of grain rotting while people starved to death by the millions. We're trying to work our way away from that. Well, now we have these silos of data rotting, sometimes literally, while the hunger for information on how to solve these unprecedented problems is more severe now than at any time in the history of humankind.

Take the LANDSAT program, just as one example, capable of taking a complete photograph of the earth's surface every 18 days. It's been up there taking pictures for almost 20 years. Ninety-five percent of those pictures have never fired a single neuron in a single human brain. They just sit there stored in digital form in Sioux Falls, South Dakota, in that case, because we don't use them. That problem is going to get a lot worse before it gets better.

Look at the Mission to Planet Earth Program, which both of our committees are looking at. When it's up there operating, it will send information equivalent to the entire Library of Congress every five days. A little bit less than that. Well, if we can't even use the LANDSAT photos, how are we going to use that? Well, if you look at our ability to learn and to deal with information and analyze our brains in the terms that might be applied to a computer, you'd say that we have a low bit rate but very high resolution. The telephone company years ago decided that seven numbers was the most we could remember, and then they added three. Bit by bit, information cannot be absorbed in great quantities.

But we also have high resolution. What that means very simply is that if we're presented with a billion or a trillion bits of data all arrayed in a mosaic pattern, such as a picture, we can absorb it just like that. Supercomputers make two unique contributions to our ability to deal with information. The first is it gives us the ability to take massive amounts of information and configure it into patterns or pictures or three-dimensional moving graphics, mosaics of meaning which enable us to absorb lots of information quickly.

The second thing supercomputers enable us to do is to go into a vast ocean of information and quickly pick out those particular scattered bits which are necessary to make up one of those patterns. We're doing that now with great success. Unfortunately, our infrastructure needed to enable us to share those pictures, those patters, those graphics is not capable of doing it. In order to use one of these new machines, you almost have to be in the same building with it because our network of communications lines has been driven by supply and demand forces responding mainly to the demand for voice communication and streams of numbers—bit, bit, bit.

We face a chicken-and-egg dilemma, a very classic problem, and I would say this especially in response to Mr. Packard's query about—a very sincere question—what exactly is the Government's role here? Well, the marketplace is not conveying to us the demand for these new kinds of information services because the network to deliver them is not in place. The market is not conveying to us the demand for this new network because the information services which will be delivered over it are not yet being offered to the public. It's a chicken-and-egg dilemma.

How do we get over that hurdle? We get over it the same way we built the interstate highway system. No private company could have gone to the capital markets and raised the money to capitalize the interstate highway fund. The Government did it. Then user fees were available to keep it going on an ongoing basis. This network should be and will be privatized as soon as it is feasible to do so. You know, the NSFNET, which was referred to earlier, is now contracted out to private companies. This will operate the same way. More than that. The unique physical characteristics of this network offer tremendous opportunities. Let me explain briefly what I'm talking about there.

Fiber optic cable is the first communications media which can have its capacity greatly upgraded without putting more cables in the ground or on the poles. All you have to change is the electronics at either end—the switches, the software, the algorithms. So as the Government stimulates the development of the new switches, et cetera, necessary to upgrade the capacity of the fiber already there to build this backbone network, that technology will become available to the private sector to quickly expand the reach of the network. The same switches will be able to expand the capacity of other fiber optic cables already in place. The demand will grow. We'll unleash the forces of supply and demand in a way that will quickly expand this network far beyond the backbone pattern that will be authorized in this legislation and in the President's plan. We need to do more. We need to create digital libraries, which will also be done in this legislation, to get started on the task of configuring the information so that it is accessible through the network.

Scientists are now saying that this development, our ability to use supercomputers in this form and share the data, is so important that it has actually led to a third branch of knowledge creation, the first two being, of course, inductive reasoning and deductive reasoning. You have a theory, you test it out. You look at the world and gather facts and try to explain it. Computational science is a third entry on that very short list. We can model versions of the way the world can work and learn from it.

Some of your witnesses will explain this far better than I can, but, members of the committee, we've got the first two branches of knowledge creation handled pretty well, but this third one is going to determine the future of the world economy and the future of virtually every business in America. We need to empower our businesses and our individuals to participate fully and to compete more effectively than the peoples of any other nation on Earth.

Now, in conclusion, I will cover a lot of things in my prepared statement that I did not cover here, including the specifics of H.R. 656 and S. 272, rather, which I should be talking about, but I've worked very closely with Congressman Brown and am very proud to be his partner and Congressman Boehlert's partner and the others here who are working on that. I'm beginning to feel I've spent so much time on the generalities that I haven't gone through the specifics, but maybe since I've consumed the time I have I'll just leave that for the record and respond to any questions you might have about it.

Thank you very much, Mr. Chairman.

[The prepared statement of Senator Gore follows:]

STATEMENT OF SENATOR AL GORE
THURSDAY, MARCH 7 HEARING ON H.R. 656
THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

I am very grateful for your invitation to testify here today on H.R. 656, the High-Performance Computing Act. This bill will ensure that the United States stays at the leading edge in computer technology. It would roughly double the Federal government's investment in research and development on new supercomputers, more advanced software, and high-speed computer networks. Perhaps most importantly, it would create a National Research and Education Network, the NREN, which would connect more than one million people throughout the country, giving them access to computing power and information resources unavailable anywhere today.

These technologies and this network represent our economic future. They are the smokestack industries of today's Information Age. We talk a lot now about jobs and economic development; about pulling our country out of recession and into renewal. Our ability to meet the economic challenges of the Information Age and beyond -- tough challenges from real competitors around the globe -- will rest in large measure on our ability to maintain and strengthen an already threatened lead in these technologies and industries.

I have been advocating legislation such as this for more than one dozen years because I strongly believe that it is critical for our country to develop the best scientists, the best science, the fastest, most powerful computers, and then, to ensure access to these technologies to as many people as possible so as many people as possible will benefit from them. This legislation will help us do that. Every year, there are new advocates. This year, finally, President Bush is among them, including in his budget for Fiscal 1992, $149 million in new funding to support these technologies.

We cannot afford to wait or, to put off this challenge. Not if we care about jobs, economic development, or our ability to hold our own in world markets.

H.R. 656 provides for a multi-agency high-performance computing research and development program to be coordinated by the White House Office of Science and Technology Policy (OSTP), whose director, Dr. D. Allan Bromley, is your next witness today. The primary agencies involved are the National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), the National Aeronautics and Space Administration (NASA), and the Department of Energy

(DOE). Each of these agencies has experience in developing and using high-performance computing technology.

H.R. 656 will provide for a well-planned, well-coordinated research program which will effectively utilize the talents and resources available throughout the Federal research agencies. The technology developed under this program will find application throughout the Federal government and throughout the country.

This technology is improving our economic security by helping American scientists and engineers develop new products and processes to keep the U.S. competitive in world markets. Supercomputers can dramatically reduce the time it takes to design and test a new product -- whether it is an airplane, a new drug, or an aluminum can. More computing power means more energy-efficient, cheaper products in all sectors of manufacturing. And that means higher profits and more jobs for Americans.

Perhaps the most important contribution this bill will make to our economic security is the National Research and Education Network, the cornerstone of the program funded by this bill. By 1996, this fiber-optic computer network would connect more than one million people at more than one thousand colleges and universities in all fifty states, allowing them to send electronic mail, share data, access supercomputers, use research facilities such as radio telescopes, and log on to data bases containing trillions of bytes of information on all sorts of topics. This network will speed research and accelerate technology transfer, so that the discoveries made in our university laboratories can be quickly and effectively turned into profits for American companies.

Today, the National Science Foundation runs NSFNET, which allows researchers and educators to exchange up to 1.5 million bits of data (megabits) per second. The NREN will be at least a thousand times faster, allowing researchers to transmit all the information in the entire Encyclopedia Brittanica from coast to coast in seconds. With today's networks, it is easy to send documents and data, but images and pictures require much faster speeds. They require the NREN, which can carry gigabits, billions of bits, every second.

With access to computer graphics, researchers throughout the country will be able to work together far more effectively than they can today. It will be much easier for teams of researchers at colleges throughout the country to work together. They will be able to see the results of their experiments as the data comes in, they will be able to share the results of their computer models in real-time, and they will be able to brainstorm by teleconference. William Wulf, formerly Assistance Director for Computer and Information Science and Engineering at NSF, likes to talk about the "National Collaboratory" -- a laboratory without walls -- which the NREN will make possible. Researchers throughout the country, at colleges and labs, large and small, will be able to stay on top of the latest advances in their fields.

The NREN and the other technology funded by H.R. 656 will also provide enormous benefits to American education, at all levels. By most accounts, we are facing a critical shortage of scientific and technical talent in the next ten years. By connecting high schools to the NREN, students will be able to share ideas with other high school students and with college students and professors throughout the country. Already, some high school students are using the NSFNET to access supercomputers, to send electronic mail, and to get data and information that just is not available at their schools. In this way, the network can nurture and inspire the next generation of scientists.

But, economists, historians, and literature majors are also discovering the power of networking. In the future, I think we will see computers and networks used to teach every subject from kindergarten through grad school. I was recently at MIT, where I was briefed on Project Athena, a project to integrate computers and networks into almost every course at MIT. Students use computers to play with the laws of physics in computer models, to test airplane designs in wind tunnel simulations, to improve their writing skills, and to learn foreign languages. Many of the ideas being developed at Project Athena and in hundreds of other experiments elsewhere could one day help students and teachers throughout the country.

The library community has been at the forefront in using computer and networking technology in education. For years, they have had electronic card catalogues which allow students to track down books in seconds. Now they are developing electronic text systems which will store books in electronic form. When coupled to a national network like the NREN, such a "Digital Library" could be used by students and educators throughout the country, in underfunded urban schools and in isolated rural school districts, where good libraries are few and far between.

I recently spoke to the American Library Association annual meeting in Chicago and heard many librarians describe how the NREN could transform their lives. They are excited about the new opportunities made possible by this technology.

The technology developed for the NREN will pave the way for high-speed networks to our homes. It will give each and everyone of us access to oceans of electronic information, let us use tele-conferencing to talk face-to-face to anyone anywhere, and deliver advanced, digital TV programming even more sophisticated and stunning than the HDTV available today. Other countries, Japan, Germany, and others, are spending billions of install optical fiber to the home, to take full advantage of this technology.

With this bill we can help shape the future -- shape it for the better. This is an investment in our national security and our economic security which we cannot afford not to make. For that reason I was very glad to see the Administration propose a High-Performance Computing and Communications Initiative, a program very similar to the program outlined in H.R. 656. I intend to work closely with Dr. Bromley and others within the Administration as well as my colleagues in Congress to secure the funding needed to

I look forward to working with my colleagues on the Science Committee towards passage of this bill.

Mr. **Boucher**. The Chair thanks the Senator for that very well stated view of the need for the high-performance computing and networking initiative. What I think we all agree on is the need for the initiative. What perhaps there is not total agreement on is the need for the legislation itself, and what I would ask the Senator is perhaps to share with this committee some of the specific reasons that we should pass legislation in order to provide a framework into which this high-performance computing initiative can fit.

Senator **Gore**. Well, let me just give one example. The Administration's plan does not include the concern expressed earlier by Mr. Gilchrest about education. Not intentionally; it was an understandable oversight which they will remedy next year, I'm sure. But that's an example of how Congressman Brown's bill and its companion in the Senate can supplement what the Administration has done, just as they have supplemented some of the things that we started here.

Dr. Bromley has done well in getting a commitment from OMB to support this initiative. But you know what? That commitment is only for one year. This is a five-year program. This committee has the power with the concurrence of the Congress to authorize a program for five years and to send a clear and unmistakable signal to the private sector that this is going to happen. And it will happen, and I have great confidence in Dr. Bromley, but I also understand that any Administration—and we Democrats have certainly been guilty of this just as much as Republicans as they've had the White House—whenever we've controlled the Presidency, our President has often stated a preference to have the Congress just appropriate the money and get out of the way. "Just give us the money and don't worry about how we spend it. Trust us, we'll do it."

Well, I trust them, but the conditions that led OMB to sign off on this this year could potentially change next year. I've known Offices of Management and Budget to suddenly do irrational things and say, "Well, yes, we liked that program last year, but we've got some hard choices, and we're just going to have to cut it out this year." We ought to be willing to say here in this Congress, "This is important to the future of this country, and we want to get on with it."

You know, there's a private company already looking at what we're doing based in Michigan. I know Congressman Henry had another hearing to go to, but the MERIT consortium in partnership with MCI and IBM have already announced a non-profit corporation in the private sector to say, "As soon as this network is up and going, we're going to commit a lot of money privately to quickly expand it as far as we can." So that's yet another reason why we need that multi-year commitment.

Now, finally, in response to your question, we've spent a lot of time in Congress, especially in this committee, looking at exactly how this should be done, and the Congress must be an integral part of this whole initiative, as it has been from the start.

Mr. **Boucher**. The Chair thanks the gentleman and recognizes the gentleman from North Carolina, Mr. Valentine.

Mr. **Valentine**. Thank you, Mr. Chairman.

I must say, Senator, that I'm proud to have known you when you served on this committee. I don't mean to suggest that you have become better at expressing yourself since I first admired that quality here, but I want to compliment you on the job that you have done here. You have succeeded, I think, in translating a lot of very complicated scientific words into language that is easy, relatively speaking, to understand.

I want to ask just a couple of questions, and maybe both of them have some parochial basis. Our district includes— the Second District in North Carolina is very much like many others but very different in many ways in that it has Duke University and the major developed part of the Research Triangle Park, and then it has a lot of rural, isolated areas in the eastern part of our State. Let me comment before coming to my question. It is certainly hoped that when we develop the ability to plug in these small, isolated high schools into the Library of Congress, and even the homes, that we can also do something about the motivation to cause that plug to be utilized rather than some other electronic devices that will be in those places.

I understand how this legislation will apply to places, certain parts of our district, but what are your ideas as to how this can assist your constituency in the hills of eastern Tennessee and my folks in Vance County, North Carolina, which is a relatively remote agricultural area?

Senator GORE. Well, that's probably the best question of all because it strikes right at the heart of what my concern is all about. I want children in Carthage, Tennessee, population 2,000, to be able to get the educational advantages that will come from these stunning developments. I don't think it is feasible for the Federal Government—and I know you're not suggesting this; this is a way of leading into my answer—I don't think it's feasible for the Federal Government with taxpayer money to build a network reaching into every home in the country. Everybody realizes we can't do that, shouldn't try to do that. But it is possible for us to demonstrate what can be done and unleash forces within the marketplace which will inevitably lead precisely to that result.

Now, as an aside, let me say that I've supported, along with Congressman Boucher, a very controversial bill which we're not discussing here today that would allow cable television—I mean telephone companies to get into the cable television business, and that's another way to unleash market forces to put fiber to the home. But that bill has uncertain chances of passage, and we understand that, but that is an example of unleashing the forces of supply and demand.

Let's assume that bill doesn't pass. Let's assume it does not pass. I believe that when graduates of the University of North Carolina have the experience of dealing with knowledge in this revolutionary form and then go to a community that's just five miles off the trunk line, and the other businesses and people in that community begin to share the understanding of how important it is for their community to have that, there will be a number of private companies interested in extending that fiber to that community.

You know, my home town is not on the interstate highway system like a lot of cities are not, but once it was built, States and localities and, in some cases, even private turnpike companies built access roads to get to it because it was there. I went to Research

Triangle recently to talk with the scientists there who are pioneers in this new computer display technology called "virtual reality." Very, very exciting. It's got a lot of attention in the press, and it really is one of the most powerful ways to present information that's ever been created. That can be taken by fiber out to schools in the rest of your district and in the rural areas of my State.

Mr. VALENTINE. One final question. Thank you. Give us the prospects for this legislation in the Senate. You know, the Senate to most of us is a strange and unusual place.

[Laughter.]

Senator GORE. I don't know how you could get that impression, Mr. Valentine.

[Laughter.]

Mr. VALENTINE. What do you think the prospects are? How long will it take, if you can say?

Senator GORE. Well, this is on the priority list and on the listing by the majority leader of our priority measures this year. It was listed as one of the high priorities, and the notation afterwards was "minimal controversy." We passed it unanimously last year. There are disagreements with the Energy Committee about the role that the Department of Energy will play in the network.

Dr. Bromley has had similar controversies with the Department of Energy in his efforts to get the Administration all unified. The Department of Energy has agreed to the plan that Dr. Bromley has presented, and that is the bureaucratic relationship which is encompassed in H.R. 656 and S. 272. We anticipate that that remaining controversy will be resolved quickly this year and that we will pass this legislation early on, and I welcome the challenge of 100 days that Congressman Brown laid down.

Mr. BOUCHER. The Chair thanks the gentleman.

The gentleman from Oregon—California, Mr. Packard.

Mr. PACKARD. Thank you very much.

I appreciate you addressing briefly the concern that I expressed relative to the role that Government would play. I'd like you to elaborate, if you would, Senator, briefly on how your legislation—what is the Government's role in terms of ownership, in terms of operation of the network after it's implemented, and how that will articulate with the private sector and the university systems as it moves from a Government program to a private program.

Senator GORE. Mr. Packard, those are questions I've spent a lot of time on. Let me begin my response by saying I believe it's noteworthy that the private companies which one might expect to be most concerned are supporting the legislation. MCI, Sprint, AT&T, et cetera, are supporting the legislation. One of the reasons is that all of the principal sponsors have said from the very beginning and reaffirmed at every occasion our full and unqualified intent to transition this into the private sector as soon as it becomes feasible to do so. Also, the NSFNET model provides reassurance because a transition has taken place there on terms satisfactory to companies like Sprint, MCI, AT&T.

This network will present some unique challenges. We do not yet know how to answer all of the questions encompassed in your query, but the old saying "Where there's a will, there's a way" certainly applies here, and the close consultation and communication with those companies that are naturally involved in this debate will continue. The NSFNET model presently serves as the model of choice with whatever wrinkles are necessary as we discover that it doesn't exactly apply. I could just say we'll do it that way, but I want to tell you I'm convinced there are differences, and we need to just acknowledge that we don't know all those answers yet.

Mr. **Packard**. Well, I certainly don't disagree with the role that Government needs to play initially. I think, though, one of my concerns not only in this program but in many of our Government programs—NASA as well as many of our other science research programs—is with the transition. We will never really remain competitive internationally until we allow—unlock the private sector to do what Government can often provide the seed money for as well as the ingenuity initially. But until the private sector really becomes a part of it, we just simply cannot remain competitive. That's true on our launch services. It's true in many of our space programs. It will be true in this case, and that's, of course, the reason for the question. I certainly applaud the efforts that the legislation lends itself to.

Senator **Gore**. Mr. Chairman, at the risk of taking too much time in response to this, please allow me to answer your question on another level. The reason capitalism has routed communism in the philosophical war of this last half-century can be seen partly in information terms as well. Capitalism allows control over the information about supply and demand, the decisions over the future course of our economy, to be dispersed as widely as possible among the people who are closest to the information. That's one of the main reasons capitalism is superior. Communism failed because it relied on a single processor of economic information, and it's inefficient. It doesn't work, and it doesn't unlock the higher fraction of human potential in creativity.

The same thing is true with computer science. We need to give this country the advantages of—we've already given it the advantages of capitalism and democracy, or our founders did. We need to make sure that our approach to computers is the same way and not just have them in these single institutions that people have to go to, but disperse it widely with this network.

Mr. **Packard**. Thank you very much.

Mr. **Boucher**. The Chair recognizes the gentleman from California, Mr. Brown.

Mr. **Brown**. Mr. Brown is going to pass.

Mr. **Boucher**. All right.

The gentleman from Maryland, Mr. Gilchrest.

Mr. **Gilchrest**. I almost feel like I should pass, too, but I'll ask my question. Sometimes I feel I should pass because I'm inadequate as far as my knowledge is concerned toward these fantastic and wonderful things. I will say that the spread of information, I think, has continued this experiment called democracy because people have access to it, and maybe we should put a television in everybody's home in Iraq and show them "Family Ties" and gradually they'll evolve into our democratic philosophies. But the spread of information is paramount. I don't mean to make light of that because I couldn't agree with you more on that particular topic.

This is a more mundane question, I suppose. Some of the problems in developing this network perhaps will be managerial problems, finding the right facility for connecting the network of these supercomputers, and so on. Is there any thought given to—we are now in the process across this Nation of closing bases and military facilities and labs, and many of these military labs have the infrastructure that might be needed in connecting some of these—making it possible for this network to work. Would it be possible to consider some of those military labs that are on the docket to be consolidated or closed to be turned over to a research university to be used—or they could take it over, in other words—the private sector could take over some of these military labs where the infrastructure is already established to be a part of this network of supercomputers.

Senator GORE. That's a very interesting idea, Mr. Gilchrest. I'd like to reflect on it. Just briefly, one of the theorists in this area, Dr. William Wulf, has long talked about a national "collaboratory" because the definition of laboratory really changes with this network, and people in locations like the ones you mentioned could have upgraded capacity because they could share with the people in other locations in a co-laboratory where the work exists within the network. So it's something that is worth exploring, and I'd like to reflect on it.

Mr. GILCHREST. Thank you, Senator Gore.

Thank you, Mr. Chairman.

Mr. BOUCHER. The gentleman from Arkansas, Mr. Thornton.

Mr. THORNTON. Thank you very much.

I do want to again express my appreciation for the splendid work that has been done in bringing this forward. I sometimes wonder if we're not perhaps at the stage where the automobile once was as an early developing instrument of transportation and communication, and highways had to be built for those automobiles to travel. And I wonder if the possibility of home computers using digital codes and fiber optics as a means of communication may not really be at the stage of early automobiles. And are you describing the need to develop a transportation system, a highway system, so that these private uses may be employed?

Senator GORE. That's right on the money. Just exactly right, as far as I'm concerned. In fact, the interstate highway analogy was the way I first started thinking about this, and I think that's most appropriate.

Mr. THORNTON. In the interest of your time, I'm not going to pursue further, but I would be delighted to add my support to this legislation and also to work with you and the Chairman on your fiber optics program.

Senator GORE. Congressman Thornton, it's a great thing for this committee and all of us to have your services back here in the Congress. It's a great pleasure to serve with you again.

Mr. THORNTON. Thank you very much.

Mr. BOUCHER. The Chair thanks the gentleman.

The gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you, Mr. Chairman.

Senator, there are some people whom I've heard— especially out in California—who actually don't like the highway system and think that the U.S. highway system screwed things up.

[Laughter.]

Mr. **Rohrabacher**. In fact, some people and a lot of environmentalists in California have made these arguments in our universities that—and I'm not making them necessarily; I mean, I think some of the points that you've made are interesting, and I'm going to watch this legislation very closely, and I have not really made up my mind as to which way to go on this—

Senator **Gore**. Well, commuting by wire as an alternative to the clogged highways has been much discussed and will become more of a reality with this.

Mr. **Rohrabacher**. Well, and there is some argument that perhaps other modes of transportation might have been developed that might have been better for the environment had we not put the money in, and sometimes when the Government starts directing the future rather than leaving it up to the people, sometimes it makes mistakes, and when it makes mistakes it really makes big mistakes.

For example, also—another example might be the railroad system where when the Government was deeply involved in the railroads, compared to those railroads which were just totally private operations, the Government-directed railroads where we helped them out actually cost a lot of money and there was a great deal of corruption back in the last century.

Let me just ask you some specific questions, and again, I'm not really stating a position on this because I don't have a position on it yet, and I'm fascinated by some of the points you've made today, and I think you've made your case very well. But does your legislation envision that the Government will be buying and owning supercomputers, high end switches, fiber optic cable, and other hardware? Do you envision that the Government is actually going to own this hardware?

Senator **Gore**. For the backbone network, the Government will do this, but it will be transitioned into the private sector as soon as it is feasible to do so. Just as the Government stimulates the development of new technologies on a demonstration basis and they become available in a lot of different fields, that would be the case here, and the switches that would be a part of the backbone network would then be available to anybody in the private sector who wanted to buy them.

Mr. **Rohrabacher**. Could you please, as you see it, tell us the difference between what your approach is and what Dr. Bromley will tell us is the approach of the Administration?

Senator **Gore**. The approaches are—

Mr. **Rohrabacher**. The central difference.

Senator **Gore**. They're very, very close because of the reasons I outlined earlier. We've worked together for a long time now. The central—we have education as a major component of ours, and they don't disagree with that. They think that that ought to be added. But the major difference, I guess, is the often-stated preference by Administrations controlled by both parties that the Congress simply appropriate money and not give any direction as to how to spend the money. That's really the only remaining difference, and they're not going to war over that one.

Mr. **Rohrabacher**. All right. Just one note. Your approach to fiber optics in terms of deregulating certain elements of the telecommunications industry I believe is an approach that we could afford now in terms of solving a certain problem without using Government funds, and many times instead of appropriating hundreds of millions of dollars some of the things might be accomplished by giving tax incentives or clearing away regulation. I will be looking at this issue very closely to see if this approach is necessary in terms of the allocating of funds or if there could be another approach with actually deregulation and tax incentives.

Senator **Gore**. Let me clarify, if I might. The entrance of telephone companies into the cable TV industry would be useful, in my opinion, to get that last mile to the home of fiber, but that development, as unlikely as it is to occur, if it did occur, that would not stimulate the development of the switches and the software and the algorithms and the national network involved here, nor would it establish the digital libraries or the educational component of this legislation or the other features of it.

I might also say that in connection with the concerns about the private sector, again it is noteworthy that the private companies with the most at stake in this whole field and all the related fields are almost unanimous in their support of this initiative. Many of them have made statements like "This is the single most important thing this country can do for our future." It has attracted very broad support within the private sector.

Mr. **Rohrabacher**. Well, I appreciate your testimony, and we'll look very closely at the legislation.

Senator **Gore**. Thank you.

Mr. **Boucher**. The Chair thanks the gentleman.

The gentleman from Illinois, Mr. Bruce.

Mr. **Bruce**. Good testimony, great questions, and I will yield to another member. Thank you.

Mr. **Boucher**. The Chair thanks the gentleman.

The gentleman from Oregon, Mr. Kopetski.

Mr. **Kopetski**. Thank you, Mr. Chair.

Senator Gore, I'm very impressed with your testimony as well. I represent part of Oregon where we have Hewlett- Packard and Mender Graphics and part of Techtronics, some of the leading edge companies in the world in some of their technologies that they have developed, and our State is also developing an education network as a State resource for providing education and seminars throughout the State using computer technologies. We also know from the high-definition television issue that Japan, for example, decided 10 years ago or 15 years ago to get into HDTV. We didn't. Now we're trying to catch up.

My question to you is what if we don't do this? What does this mean in terms of Japan and Germany? What are they doing? What are the consequences for the United States if we don't have a coordinated approach?

Senator **Gore**. First, as an aside, we have an opportunity to blow Japan out of the water on HDTV because they have gone with the analog approach, and we are demonstrating now something called

VHDTV—very high- definition television—based on the digital technology, which this very network and related developments will make it possible for us to exploit to the detriment of these analog investments by the Japanese. But if we do not have the boldness to take advantage of the areas where we do have a lead, then we'll watch that lead go over to the Japanese and others who do have that boldness. We have about an 18-month lead here.

The Japanese are now at work trying to put in place a fiber network linking every significant factory on all the islands of Japan in a grid that will enable them to shift work around to computer-controlled machines that have slack capacity among the other things they're planning. They're also planning to take fiber to every home. So if we don't move to exploit the advantage we have, then we'll lose the advantage. It's a simple as that.

Mr. **Kopetski**. Thank you.

Thank you, Mr. Chair.

Mr. **Boucher**. The Chair recognizes the gentleman from Indiana, Mr. Roemer.

Mr. **Roemer**. Thank you, Mr. Chairman.

Thank you, Senator, for taking time out of your schedule, too, and coming over here. I know that there are other freshmen on this committee. Given the prominence that you have gained from your hard work on this committee, we take a lot of energy and skill in following your example here.

One of the questions I have for you, Senator, is in looking at section 5 of H.R. 656, we see all the different agencies that are coordinating together. Let me just name a couple of them: the National Science Foundation, the National Aeronautics and Space Administration, the Department of Energy, the Department of Defense, and other relevant agencies, and then they are coordinated through the Federal Coordinating Council for Science Engineering and Technology.

Following up on my colleague from Oregon's question, and not in terms of emulating the Japanese—I don't think that many of our solutions in education or trade are in emulating the Japanese—but do we need to get some other way within the Department of Commerce or some other agency to better coordinate our trade in long term development of getting our products from the research and development stage to the commercial application stage, whether it be fiber optics, high-definition television, superchips, magnetic levitation trains?

Senator **Gore**. Well, Congressman, thank you first for your kind words, and your question is a broad one and a very appropriate one. I personally support some kind of civilian DARPA. I don't have specific suggestions for you here this morning about how to do that. I recognize there would be a lot of concerns about it, and I'd want to reflect on those concerns. But I think we do need an American model for competing more effectively.

Now, where that relates to this project—I want to come back to this for a minute in the context of your question— one of the advantages we have with this effort is quite a few years of experience in working out exactly how these agencies can coordinate their efforts, and there is, as Dr. Bromley will tell you, a very impressive working relationship between all of the departments and agencies involved. You might look at the organizational chart and ask yourself, "How in the world can this thing operate the way it does?," but the fact is it does because all of the key players are making it operate, and they've worked out the thousands of subtle arrangements at a, you know, sub-cabinet level that make the information flow smoothly and make the decisions in a timely way.

This model is one that is proven to be successful. That is why it is in the legislation that Congressman Brown and I have introduced.

Mr. ROEMER. Senator, just to—and I know, you know, maybe there's something that you and I can work on in the future, and if you do have any immediate comments on what kind of role you might see for DARPA, as a staff member on the Senate side, I work closely with DARPA. I know that there has been some ongoing give-and-take and tugs between the Reagan Administration and what role DARPA would play. Do you have any immediate comments? And if not, that's fine, but I would sure like to—

Senator GORE. I'd like to follow up with you.

Mr. ROEMER. Okay.

Senator GORE. Perhaps we could work together on this initiative. I would welcome a chance to do that. We used to have a kind of civilian DARPA in DARPA, but he was fired.

[Laughter.]

Senator GORE. And I regretted that.

Mr. ROEMER. I look forward to it, Senator. Thank you again.

Senator GORE. Very good.

Mr. Chairman, thank you so much. I apologize to the other witnesses for the time I've consumed in my responses, but thank you. Have I forestalled?

Mr. BOUCHER. We have one other member present—

Senator GORE. I'm sorry.

Mr. BOUCHER.—who I'll call on. He's shaking his head, the gentleman from Iowa.

The Chair thanks Senator Gore very much for the enlightening testimony this morning, and I would simply like to underscore a comment by the gentleman from North Carolina that you do have an exceptional ability to take technical concepts, translate them into understandable language, and I think that was a very remarkable presentation this morning.

Senator GORE. Are you getting all this down?

[Laughter.]

Senator GORE. I appreciate it, Mr. Chairman. Thank you.

Mr. BOUCHER. Thank you, Senator.

Mr. BOUCHER. Now we are pleased to welcome to this joint hearing the President's science advisor, Dr. D. Allan Bromley, and we will be very pleased, Dr. Bromley, to hear your comments concerning the Administration's position with regard to the high-performance computing and networking initiative, and without objection, your written statement will be made a part of the record, and we'll be pleased to hear your summary.

STATEMENT OF D. ALLAN BROMLEY, SCIENCE ADVISOR TO THE PRESIDENT; DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, WASHINGTON, D.C.

Dr. **Bromley**. Thank you very much, Mr. Chairman. It always is a great pleasure—

Am I connected? Okay.

Thank you very much, Mr. Chairman—both Chairman Valentine, and Chairman Boucher, members of the two subcommittees.

It's a great pleasure on this particular topic to follow Senator Gore, because he has given you a very elegant presentation—a very elegant and eloquent presentation of much of the background that I would otherwise have wished to present. As Director of the Office of Science and Technology Policy, what I would like to do is simply give you some further detail as to the Administration's initiative, the President's initiative, and I would comment then on two concerns that I have with respect to the legislation under consideration here this morning.

I think that it is important to recognize that the prominence given to high-performance computing and communication in the budget that the President forwarded is a very real indication of the importance that he attaches to it and that we in the Administration attach to this effort. Indeed, personally, I can think of very few other activities that we, collectively in this Nation, could take that have the potential for such a great impact on our society; so it is with very real pleasure that I appear before you this morning, and I want to tell you something about this initiative. How it was developed, and what it contains.

The overall goals of high-performance computing and communication are symbolized in the document that we have made available to you, the document entitled "Grand Challenges: High-Performance Computing and Communication," problems of very high scientific and social value that we simply can't attack in effective fashion at the present time. These are very important problems. They are within our reach technologically, but in order to make them accessible, we must move forward with the kind of program and the kind of initiative that the President has set forward.

What we have in mind is the full integration of component programs in all of the major Federal agencies, bringing them together into a national program—as distinct from a combination of heterogeneous agency programs—that will move us forward in the directions that Senator Gore described just before me. The initiative proposes that we should increase our support for this activity across the spectrum of the agencies by 30 percent in moving from what was appropriated in 1991 to what we have requested in 1992.

It is also our goal to double the investment in this area over the five-year planning period that is reflected in the document that we have made available to you. During that period, we wish to increase the speed, the memory capacity, and the information transfer rates by factors between 100 and 1,000. Those factors are within reach technologically, and those factors can make not just a quantitative difference in what we can do, they can make a very major qualitative difference as well.

As Senator Gore spelled out for you, this is not a new initiative. The whole high-performance computing and communication initiative dates back to the early 1980s and before. I think originally it was a recognition in the scientific and technological communities that simply they had reached barriers in their approach to the most important problems in field after field and that they could not proceed without substantial improvement in the computational facilities available to them. It was in 1982, under a request from this committee, that the Federal Coordinating Council examined the status of supercomputing in the United States, reviewed the role of the Federal Government, and there were several subsequent years of reports, studies and planning that culminated in September of 1989 in the issuance of a report, by my office, entitled "The Federal High-Performance Computing Program."

What we have brought forward for you in the 1992 budget is the detailed plan for implementing the program that was discussed in broad outline in that earlier report. Eight major agencies are participating in this program. The program, if implemented, will of course affect all of the Federal agencies. But the thing that I want to emphasize here—and pay tribute—to is the remarkable level of mutual trust, of cooperation, and of synergism that has been developed among those eight agencies over the period of the last year, two years, as they have worked on a weekly and sometimes daily basis to put together the initiative that we bring to you.

What has been involved here is not just simply looking at one another's program. What is involved here is actually taking the programs of each agency, looking at them in detail, if necessary taking them apart, rebuilding them, restructuring them so that they fit into a coherent whole so that we get the maximum impact for every dollar that we can invest in this area, every dollar that you gentlemen can make available to us. I think that we have here an example of participation and cooperation that is unique both within and outside of Government. It is, I think, also an indication of what we can accomplish under the new and restructured Federal Coordinating Council where the members are now Cabinet Secretaries, Deputy Secretaries, and the Heads of the Independent Agencies so that once decisions are made in the committees of the FCCSET and are approved by this group of members, then the decisions remain intact through all subsequent budget negotiations. This gives me a much greater degree of confidence that this program will in fact move forward as it is presented to you and as it has been agreed to by all of these FCCSET members.

There are four specific components in the program that we are proposing, and there has been some confusion, I believe, as to what those components comprise; I want to take just a moment to run through the four.

The first has to do with high-performance computing systems, and you will note, ladies and gentlemen, that I do not use the word "supercomputer." We are talking here not only about supercomputers but about high-performance computers of all sizes and kinds because on our ultimate network we will have a great many different kinds and sizes of computers; in the final system the user should not either care or know what computer is actually doing work for him or for her because it is one of the fundamental truths of computer science, computational science, that different problems require quite different architectural structures in the computers that work on them if they are to be done with maximum efficiency. So one of the goals is to demonstrate the working of a complex system that involves a great many kinds of high-performance systems.

Another part of the program is to make sure that we use the purchasing power of the Federal Government in a coherent way to provide for a viable domestic industry on a continuing basis to maintain our leadership and our innovative potential in the development of this kind of hardware on the leading edge of computer science. We have a leadership role, and it's one that we can keep. It is also one that we can easily lose.

The second component of our program recognizes that no matter how powerful is the computational system, if the software—if the actual interface with the user—is not friendly, then it isn't going to work. And the one thing you can say about supercomputers and high-performance computer software is that in general it is not user friendly. It has been developed by mavens who work on nuclear weaponry and on high-performance aircraft, and the average individual would have a rough time getting these programs to perform. We have a real challenge here. This again is an area where we have international leadership, but an area of leadership that we could easily lose.

Thirdly, the area where there is perhaps the greatest misunderstanding and potential for confusion is that relating to the information highway that Senator Gore just discussed. The idea here is clearly, in the end, to make the kind of power that I've been discussing and the kind of software for use of that power available across the Nation to any citizen who wants it, to any home that wants it, to any school, to any small industry, as well as to the major industries and the major laboratories that now have it. But it is important to realize that the Government is not going to provide that; we are not suggesting that.

What we are suggesting is that we develop here a National Research and Education Network—that's what NREN stands for — and I would simply emphasize that education has been part of our program from the very beginning. We did not amplify to a great extent, in this report, on the educational potential, although I would be happy to do so in response to questions, because in parallel with this activity—and I hope that many of you gentlemen have already seen the report — the FCCSET organization was producing a report on education and human resources that was highlighting that particular role, and we did not wish to duplicate between the two reports. Rather, we are focusing again on maximizing the coordination not only among agencies in a particular area of activity like high-performance computing but rather among agencies in a great many areas which overlap and which have common links. This is just an example.

What we have—and this is important to understand—is a system that began with networks that were within single agencies. DOE had a net. The Department of Defense had a net, NSF had a net. These were all pulled together to become Internet. Internet was managed by NSF. And what we propose is that that Internet be expanded substantially, in terms of what it has in the way of hardware to provide capacity, what it has in the way of off-ramps to make capacity available to a great many organizations and institutions that don't now have it.

But it is important to recognize that even in this network the Government does not own the fiber, that we have gone to the commercial carriers, and they have the fiber. It would be my hope and certainly the plan that we outline here that in the ultimate system it would be a public utility in exactly the same sense that the telephone system is a public utility; not only that, it would be as commonplace, as natural to have in your home and to use in your home as the telephone. That is the only way, ladies and gentlemen, that we can be truly competitive in the world that we face as we move into the next millennium, and we have the opportunity to move into that millennium with real leadership.

The fourth component of our program is no less important than the first three, and that has to do with the people who will not only move this area forward, who will be the leaders in computer science not only nationally but world-wide, the leaders in computational science, but equally important and all too frequently forgotten in our entire approach to science and technology is the forgotten middle—the technicians, the folk who come usually from two-year colleges who actually operate the network, who maintain the network, who maintain the computers that are on the network—and unless we act aggressively to improve our rate of production of people in that category and unless we give them more prestige, a greater reward structure, more recognition, we will in fact have a major gap in the program that we are bringing to you. This is a very important part of the initiative.

What we seek—just to give some specific goals—is 1,000-fold improvement in useful computing capacity, and we seek that within the next five years. That means that we will be doing one trillion operations per second, and the focus we would like to see is on generic technologies that are applicable not specifically to this program but to a great many programs but also happen to be crucial to this one. From the very beginning, we want to see the private sector involved to the maximum possible extent. This is important for two reasons. One, because they bring their own experience, expertise, leadership to bear on the initiative, and secondly, because if they are involved from the beginning, I believe that we can move this entire program into the public utility that I foresee in the future on a much more rapid basis than would otherwise be the case.

In software development, we're going to focus on these Grand Challenges because by doing so I think we will be able to demonstrate in a way that is quite unique—I wish I had the opportunity to show you this morning some films made in some of the Nation's supercomputer laboratories showing the totally new capacity that becomes available with this high- performance systems, because we can demonstrate to the entire Nation that there are a great many things that they can do that they can't have right now, and this is what we need to get public support for the entire program.

I've said that we're going to try and expand the Internet to a national research and education net, and the goal there is to get a

100-fold increase in the rate at which data can be transmitted. We want to have levels of gigabits per second. Obviously, we have to expand the number of on- and off-ramps so that a great many more people get access to the system.

Small businesses, in my view, are one of the most important groups to consider because they are the ones who can probably use this with the highest effectiveness in creating new jobs, in moving forward the innovation that they already demonstrate to a very high degree in this country. The second most important area, as far as I'm concerned, is the secondary and elementary schools of the Nation because, as Senator Gore touched on, a single fiber entering a school room makes it possible for every student in that room to receive individualized, self-paced instruction in any topic with reinforcement where appropriate, with repetition where necessary, and with the kind of new graphic presentations that can really grasp the enthusiasm and interest of youngsters. That in the long run is probably the most important thing we can possibly do.

I would have to say that no plan of this kind is any better than its execution, and the execution of this plan, I believe, will rely very heavily on the synergy that's been developed between the agencies that are involved in its creation. What we have tried to do is allocate the responsibilities in this program so that each agency is responsible for the area in which it has the greatest experience, the area in which it does best. That is the sort of thing we have tried to do in all of the FCCSET activities, namely to maximize the critical effectiveness of our activities by drawing on the special expertise of each of the participating agencies.

I don't think I have to recite for you again the long list of "hoped for" benefits that we foresee; "hoped for" is far too pessimistic. I am absolutely confident that the benefits that Senator Gore spelled out for you will arise, and I will not attempt to do that. I think it is important also to mention that although the numbers are very crude, back in 1989 we contracted with Los Alamos to do a study to try to give us some feeling for the economic benefit that would be reflected if you gentlemen were to agree to support the program we're talking about here. I emphasize that this kind of economic modeling is open to considerable question and error, but it is important to note that the result that has come out of this study is that the payback is in the range— according to the group that studied it—from $170 billion to $500 billion over the next decade. And those, despite the fact that they may be wrong by significant factors, are still very impressive numbers and would represent a very significant payback.

With respect to the legislation both in the Senate and here in the House, I would say, first of all, as Senator Gore said in response to some of your questions, that the goals that are outlined are goals that we fully share, that the programs are remarkably similar. I have, however, two concerns, and let me be very candid and explicit about those concerns.

The first concern is that this is an area perhaps par excellence in the whole field of technology that is moving very rapidly. It is the intention of our Administration group to revisit this plan on at least an annual basis and change it as appropriate to the changing technology and to the experience we have gained up to that point.

If that flexibility for change along the way is not retained, then I am concerned because we will not be able to move forward in the optimal fashion to use what technology can make available to us. I register that simply as a concern, and it's something that we must, I hope, address jointly to make sure that we don't lose that flexibility.

The second concern I have reflects the simple fact that the major players in this program come before different committees of the Congress. We have spent a year hammering out differences among the agencies and have arrived at a point where all of the participating agencies and their senior personnel—their Secretaries, their Administrators, whatever is appropriate—have agreed to participate in the program as indicated. Now, should it turn out that, for whatever reason, different committees choose to act differently on various components of this, the cohesion that is all important in the program that we bring forward could very rapidly disappear. This would require the group to go back and rework the plan essentially from scratch to maintain the maximum benefit under new conditions and perhaps new assignments of responsibility.

I would raise that too only as a concern, and I would hope that working together with you gentlemen and your colleagues in other committees that we can hope to get the kind of cooperation and coordination that now exists in the agencies in bringing forward the plan.

Mr. Chairman, let me conclude my remarks at that point. My formal testimony contains considerably greater detail, but I would welcome your questions.

Thank you very much, Mr. Chairman.

[The prepared statement of Dr. Bromley follows:]

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS

TESTIMONY

OF

D. ALLAN BROMLEY

DIRECTOR

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

BEFORE THE

SUBCOMMITTEE ON SCIENCE

SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

MARCH 7, 1991

Chairman Boucher, Chairman Valentine, and members of the subcommittees:

Thank you for giving me the opportunity, as Director of the Office of Science and Technology Policy, to discuss with you the critically important issue of high performance computing and communications.

On February 4, 1991, the President announced his proposed budget for Fiscal Year 1992. Among the major new R&D programs in the budget is a Presidential initiative on high performance computing and communications, which is described in the report Grand Challenges: High Performance Computing and Communications. The report, which was released on February 5, 1991, was produced by a Working Group on High Performance Computing and Communications under the Committee on Physical, Mathematical, and Engineering Sciences, which is one of seven umbrella interagency committees under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). A copy of the report is attached.

The overall goals of the high performance computing and communications initiative are symbolized by a set of what are called "grand challenges," problems of important scientific and social value whose solution could be advanced by applying high performance computing techniques and resources. These include global climate modeling, mapping the human genome, understanding the nature of new materials, problems applicable to national security needs, and the design of ever more sophisticated computers. Many such problems can be addressed through high performance computing and communications, including ones that are impossible to foresee today.

The initiative represents a full integration of component programs in a number of Federal agencies in high performance computing and computer communications networks. It integrates and coordinates agency programs and builds on those programs where appropriate. The initiative proposes to increase funding in these programs by 30 percent, from the $489 million appropriated in FY 1991 to $638 millions in FY 1992.

History of the Initiative

The high performance computing and communications initiative can trace its formative years to the early 1980s, when the scientific community and federal agencies recognized the need for advanced computing in a wide range of scientific disciplines. As fields of science progressed, the quantity of data, the number of databases, and need for more sophisticated modeling and analysis all grew. The Lax Report of 1982 provided an opportunity to open discussions on the need for supercomputer centers beyond those previously at the Department of Energy's national laboratories. Subsequently, the availability of such resources to the basic research community expanded -- for example, through the establishment of the National Science Foundation's and NASA's supercomputing centers.

In 1982 a FCCSET committee examined the status of supercomputing in the United States and reviewed the role of the federal government in the development of this technology. In 1985 this committee recommended government action necessary to retain technological supremacy in the development and use of supercomputers in the United States. Subsequent planning resulted in a series of workshops conducted in 1987 and in a set of reports that set forth a research and development strategy.

A synthesis of the studies, reports, and planning was published by OSTP in the report entitled The Federal High Performance Computing Program, which was issued on September 8, 1989. The initiative in the FY 1992 budget represents an implementation by the participating agencies of the plan embodied in that report, appropriately updated to recognize accomplishments made to date. The report described a five-year program to be undertaken by four agencies -- the Defense Advanced Research Projects Agency, the National Science Foundation, the Department of Energy, and the National Aeronautics and Space Administration. Four additional partners have since joined the program -- the National Library of Medicine within the National Institutes of Health, the Environmental Protection Agency, and the National Institute of Standards and Technology and National Oceanic and Atmospheric Administration within the Department of Commerce -- and they have added considerable strength to the overall program.

The planning and implementation of the HPCC program have been the result of extraordinarily effective collaboration by the participating agencies using the FCCSET forum. It was developed after several years of discussions among the agencies and hundreds of hours of negotiating and interactions between all federal government agencies with an interest in computing. Agencies have realigned and enhanced their HPCC programs, coordinated their activities with other agencies, and shared common resources. The final product represents a complex balance of relationships and agreements forged among the agencies over a number of years.

These agencies have achieved a level of mutual trust, cooperation, and synergism that is remarkable in or out of government -- and not easily achieved. In addition, the success of this effort demonstrates the advantages to be gained by using the FCCSET process to coordinate areas of science and technology that cut across the missions of several federal agencies. The FCCSET interagency process maintains the necessary flexibility and balance of a truly integrated program as the science and technology evolve, and it allows additional agencies to identify opportunities and participate in a given program.

Description of the Initiative

The HPCC initiative is a program for research and development in all leading-edge areas of computing. The program has four major components: (1) High Performance Computing Systems, (2) Advanced Software Technology and Algorithms, (3) a National Research and Education Network (NREN), and (4) Basic Research and Human Resources. The program seeks a proper balance among the generic goals of technology development, technology dissemination and application, and improvements in U.S. productivity and industrial competitiveness. It incorporates general purpose advanced computing as well as the challenges ahead in massively parallel computing.

In the development of computing hardware, ambitious goals have been set. The program seeks a thousandfold improvement in useful computing capability (to a trillion operations per second). The focus will be on the generic technologies that will prove valuable in many different sectors. Where appropriate, projects will be performed on a cost-shared basis with industry.

In software development, the program will focus on the advanced software and algorithms that in many applications have become the determining factor for exploiting high performance computing and communications. In particular, software must become much more user-friendly if we are to provide a much larger fraction of the population with access to high performance computing.

The National Research and Education Network (NREN) would dramatically expand and enhance the capabilities of the existing interconnected computer networks called the Internet. The overall goal is to achieve a hundredfold increase in communications speed (to levels of gigabits per second). In addition, the number of "on-ramps" and "off-ramps" to the network would be greatly expanded, bringing the potential of high performance computing to homes, offices, classrooms, and factories. Such a network could have the kind of catalytic effect on our society, companies, and universities that the telephone system has had during the twentieth century. A new meaning will be given to communication, involving not just the transfer of knowledge but a full sharing of resources and capabilities that no single site possesses.

Finally, the HPCC initiative will add significantly to the nation's science and technology infrastructure through its impacts on education and basic research. It is my personal view that the successful implementation of this program will lay the foundation for changes in education at all levels, including the precollege level.

Of course, no plan is better than its execution, and the execution of the HPCC initiative will rely heavily on the synergy that has been carefully cultivated among the participating agencies. This synergy has been fostered by allowing each agency to do what it does best in the way that it does best. Each of the four founding agencies has national constituencies and historical strengths. DARPA, for example, will lead in fostering the development of breakthrough system technologies, as it has done in the past for time-sharing, network operating systems, and RISC architecture. DOE, through its historical ties with the national laboratories, has always led in the development and use of HPCC technologies and is applying them on the cutting-edge of scientific problems. NASA will continue to pursue a new wave of space-related and aeronautics problems, such as computational aerodynamics, as well as its strength in the collection, modeling, simulating, and archiving of space-based environmental data. And NSF's close ties with the academic community gives it a special expertise in both education and in the coordination and use of NREN.

Expected Returns of the Initiative

The high performance computing and communications initiative represents a major strategic investment for the nation with both economic and social returns. I personally believe that few technology initiatives have the potential to have a greater impact on the ways we live and work than does the high performance computing and communications initiative.

The high-performance end of the computer market is relatively small, but its influence far transcends its size. The high end is where leading-edge technologies and applications are developed. Recent history indicates that these developments diffuse so quickly throughout the overall market that "superminis" and "superworkstations" are no longer contradictions in terms. A federal investment in the leading-edge computing technology will speed the growth of the overall computer market and may catalyze investments on the part of U.S. industry. At the same time, supercomputers are not the only important hardware component; we shall not forget the importance of the smaller, more widely distributed units and their role in the overall system.

In addition, the HPCC initiative will be a major contributor to meeting national needs. National security, health, transportation, education, energy, and environment concerns are all areas that have grown to depend on high performance computing and communications in essential ways. The dependence will grow as computers become more powerful, cheaper, more reliable, and more usable.

HPCC is also critical for the nation's scientific infrastructure. The electronic computer was born as a scientific tool, and its early development was driven by scientific needs. Business applications soon came to dominate its development, but recently there has been a renewed focus on computers as an instrument in science. Indeed, "computational science," which incorporates modeling, simulation and data rendition, is adding a third dimension to experimentation and theory as modes of scientific investigation. In field after field of fundamental and applied sciences, problems intractable for either theory or experimentation are being successfully attacked with the aid of high speed computation.

Diffusion of the Initiative's Benefits

If the HPCC initiative is to realize its full potential, it is not enough that it reach its technology goals. It is equally important that the technologies be deployed by the private sector in a timely way to result in an acceleration of market growth. It is likewise insufficient for applications to be developed and problems to be solved; in addition, the benefits accruing from those solutions must be disseminated so as to influence our everyday lives.

The continued development and use of government-funded high performance computing and communications prototypes can have a significant positive impact on the potential commercialization of these technologies. In addition, many organizations that cannot individually justify the hardware investments will be able to gain access to these new computing systems via the new network. Thus, the knowledge gained through the timely development and use of prototype systems and the access provided to them by the network will significantly improve the dissemination of the benefits of the initiative.

However, this wide diffusion is not possible by federal action alone. The Administration's HPCC initiative will serve the nation best as a catalyst for private actions. Some analysts have suggested that the HPCC initiative can spur several hundred billion dollars of GNP growth. If so, it will be because American companies, both large and small, are able to deploy the technologies in producing quality goods and services.

Similarly, some predict that NREN will lead to the establishment of a truly national high speed network that connects essentially every home and every office. If that happens, it will be because private investments are stimulated by government leadership. Far from suppressing or displacing the focus of a free market, the HPCC initiative will strengthen them by providing the impetus for vigorous private action.

Congressional Initiatives in High Performance Computing and Communications

The breadth and balance of the high performance computing and communications initiative are critical to its success. The four components of the program are carefully balanced, and maintaining this balance is the most important priority in the program. For example, powerful computers without adequate software, networking, and capable people would not result in successful applications. A program that created only high performance networks would not satisfy the need for greater computing performance to take advantage of the networks and solve important problems.

Similarly, the Administration's initiative relies on substantial participation by industry and government laboratories to overcome barriers to technology transfer. Cooperative government, industry, and university activities will yield the maximum benefits derived from moving new technologies from basic discoveries to the marketplace.

The legislative proposals pending before the Congress, though well intended, do not fully recognize the comprehensive interagency effort brought about through years of collaboration. For example, H.R.656 only specifies the program for two of the four major agencies included in the high performance computing and communications initiative. In addition, H.R.656 incorrectly specifies the roles of the agencies; many of the requirements of the legislation have, in fact, already been accomplished; and the agencies have moved on to further scientific and technical challenges. The legislation, in effect, may detract from the existing programs by limiting the activities of the agencies and by causing an unintended revision of complex relationships forged between the agencies. For these reasons, I strongly believe that FCCSET activities should not be codified in law.

I am concerned that legislative action not limit the flexibility of what is by nature an extremely dynamic process. When research plans are developed to implement interagency programs, those plans are inevitably dynamic, just as the research efforts they describe are dynamic and evolving. If research plans are codified in law, it suggests that the research is static. This is particularly a concern with high performance computing and communications, where the pace of technological change is dramatic. As an example of a fast-moving research opportunity, I might mention a joint Los Alamos National Laboratory/DARPA effort that successfully applied an innovative massively parallel Connection Machine Computer system to a nuclear weapons safety code to gain new and valuable insights into the safety of the nuclear weapons inventory. Another example occurred in the last year at the National Library of Medicine's National Center for Biotechnology Information, where researchers developed a new fast algorithm for sequence similarity searches of protein and nucleic acid databases. This was very helpful in the identification of a gene causing von Rocklinghausen's neurofibromatosis. This is a major breakthrough in the understanding of this bewildering disorder that affects about 1 in 3,000 people. On the networking front, significant achievements have also been made. For example, the NSFNET has increased in speed a thousandfold (from 56 kilobits per second to 45 megabits per second) since 1988.

H.R. 656 has as its focal point the issuing of a plan that would delineate agency roles and include specific tasks. However, the Administration's initiative and the accompanying FCCSET report satisfy these demands for items to be incorporated in the planning phase. H.R.656 further calls for the establishment of an advisory panel to provide additional input into the plan. But many of the agencies already have current advisory panels, and private sector participation is fully anticipated in the Administration's initiative as agency programs move forward to implementation. Moreover, the oversight role of the Congress, including the hearings scheduled this week in the House and Senate, serve as important elements in the fine tuning of the program.

The National Research and Education Network described in the initiative addresses the need for greatly enhanced computer communications highlighted in the legislation. The initiative also seeks to be comprehensive in addressing the roles of the various R&D agencies -- for example, by allowing other agencies to join the effort as appropriate.

It bears emphasis hat the Administration's initiative uses the existing statutory, programmatic, budgetary, and authorizing authorities of the agencies and departments involved in the initiative, including OSTP. The funding levels necessary to proceed with this effort have been transmitted to the Congress in the President's request and are clearly reflected in the budgets of each of the eight agencies involved in the initiative. The Congress already has the ability to positively affect the high performance computing program of the federal government through existing authorizations and appropriations.

FCCSET is a very important mechanism within the Executive Branch for reviewing and coordinating research and development activities that cut across the missions of more than one federal agency. Unlike the committees in the Legislative Branch, each of which has discrete authority for oversight, interagency committees within FCCSET are forums for discussion, analysis, collaboration, and consensus building. The member agencies then have the responsibility for implementing the program and proceeding with the necessary contracting, budgeting, and so on developed through the interagency process.

Several legislative vehicles, in addition to H.R. 656, have been introduced that seek to endorse and advance the Administration's initiative. I welcome the Congress' interest and intentions in high performance computing and communications. I am confident that by working together we can have a significant impact on the nation's future through these efforts, and I welcome suggestions from Congress to improve the current initiative.

I might suggest that hearings to receive the views of all the various communities involved with this proposal and a positive endorsement of this program by Congress would be of great assistance in advancing high performance computing and communications in this country. Positive action on the requested appropriations will ensure that this extensive interagency program can go forward.

Chairmen and members of the subcommittees, let me conclude by saying that I look forward to working cooperatively with you on this initiative. We share the same goals, and I am confident that we cam reach a consensus on how best to achieve them.

Mr. Boucher. Thank you very much, Dr. Bromley. We appreciate your attendance here this morning and those very well expressed views.

I wonder at the outset if you would take just a moment to comment on the potential and the time frame against which we could expect to see a commercialization of this network following the investment by the Federal Government in jump-starting the system.

Dr. Bromley. I think it is important, sir, to begin by noting that, as Senator Gore mentioned earlier, we already have Advanced Network Services—a not-for-profit organization that has been set up—supported by, but independent of, IBM, MCI, and the Merit operation out of the University of Michigan originally. That is being set up already and is poised to begin to commercialize, to begin to work toward this utility concept starting as soon as we start. So it's not going to be a process of the Government working for a time and then industry coming in. I think that it has been critical to have industrial participation all the way through the planning, and we have vehicles already in place that are ready to move as soon as we get started.

So I would see that essentially simultaneously with action—and action, I may say, sir, is already under way. It should not be forgotten that the Federal Government is already investing just about half a billion dollars a year in high-performance computing in the various agency programs, so there's a great deal of work already in place. What this initiative does is to bring it together in a coherent fashion and move it all forward, hopefully in a better and more productive fashion. But a lot is under way.

The ties with industry are already very strong, and in the Administration, in parallel with the FCCSET activity, we have activity in the President's Council of Advisors in Science and Technology. We have a panel on high-performance computing and communications chaired by Dr. Solomon Buchsbaum of AT&T, and it is very important to bring the private sector input into all these discussions from the very outset.

Mr. Boucher. Would you care to make just a comment perhaps to expand a bit upon what Senator Gore said about the need for this initiative at the outset in order to jump-start the process? To state that question a different way, why can't we simply at this point leave it entirely to the private sector? Why is the Government role really necessary?

Dr. Bromley. I think there are several reasons, sir. Perhaps one of the most important is that this half billion dollars that we are spending now has created centers of excellence in our national laboratories, in the supercomputer centers, in the major research universities, but these have been isolated, and the access to those centers of excellence by the industrial sector, with the exception of some very large industries that you could easily name, has been rather small. And so what I see as perhaps the greatest need for Federal action at this time is simply the bringing together of the excellence that we already have into a critical mass that will move us forward in a defined direction with a coherent input from all the players.

It's the problem we face in area after area. We have here in the U.S. the innovative skill, the know-how, frequently the technology, but we tend to ride off in all directions, and the major role I see for this initiative is the focusing of the activity and then the augmenting of that activity by coherent action by the Federal Government.

Mr. **Boucher**. Thank you very much.

The Chair's time has expired, and in the interest of moving the hearing along, I'll just make one further comment, and that is this. I, for one, very much welcome your suggestion that we need to work in partnership in ensuring that as we structure this legislation it not serve as a restriction or create some inflexibility on the part of the various agencies that will be coordinating the initiative, and I give you that pledge on the part of this member and would very much welcome any recommendations that you care to make on amendments that we should make to the bill at this point that would be in furtherance of that objective.

The Chair recognizes the gentleman from North Carolina.

Mr. **Valentine**. Thank you, Mr. Chairman.

Dr. Bromley, I want to say also that we from my part welcome you here. I know you think that you work for the Congress almost. You're down here so often, but that is some indication of how bad we need you.

Dr. **Bromley**. It's a pleasure, sir.

Mr. **Valentine**. What role do you foresee in the Administration's high-performance computer initiative for existing supercomputer centers such as those supported by NSF, DOE, and NASA?

Dr. **Bromley**. I see a very crucial role for them, Mr. Valentine, because they have already, in the fields in which they have been operating, demonstrated where the frontiers are and even more important where the frontiers can be, and so they are the sort of point institutions as we move forward in this initiative. So I see a very important role for them.

Mr. **Valentine**. One of the witnesses who will testify with panel four, Dr. Larry Lee, Executive Director of the North Carolina Supercomputing Center, is here today. I mentioned his name earlier, but he wasn't here to hear it. I want to be sure he understands that I welcomed him, and I welcome him again. We're very proud of him and his institution.

How will non-Federally funded supercomputer centers such as the North Carolina Supercomputing Center fit into this initiative?

Dr. **Bromley**. We have in the Nation, sir, a very tightly knit community of the people at the forefront of computer science and computational science. These are bonds of personal friendship, institutional relations that are already very strong, and so I have no question whatsoever but that we will be drawing on a great many centers that are not at this moment necessarily part of any Federal program. We will be drawing on expertise wherever we can find it in the Nation, and the fortunate thing is—typical of our structure and the way science is done in this country—all the leading people know all the other leading people and know where to get the expertise when it's required.

And so if someone has something to contribute to this program and is not already part of it, one of the early moves that we foresee is bringing them into the activity and taking advantage of their experience, giving them the advantage in turn of what we're trying to put together. I look on this as a very highly cooperative activity.

Mr. **Valentine**. Thank you, Doctor.

Thank you, Mr. Chairman.

Mr. **Boucher**. The Chair thanks the gentleman.

The gentleman from California, Mr. Packard.

Mr. **Packard**. Thank you.

You alluded, Dr. Bromley, to the changes in the request from the 1991 appropriations versus the 1992 request and the five-year plan, but you didn't mention any figures. What are the figures?

Dr. **Bromley**. We are requesting this year, sir, $638 million.

Mr. **Packard**. And last year?

Dr. **Bromley**. Last year we were just under $500 million. We're talking about a 30 percent increase.

Mr. **Packard**. And the five-year plan? What does it call for, about?

Dr. **Bromley**. The total of the five-year plan?

Mr. **Packard**. Yes.

Dr. **Bromley**. We're talking about doubling it, bringing it up to $1 billion at the end of the five years.

Mr. **Packard**. Okay. And Senator Gore referred to very modest, almost insignificant differences between S. 272 versus H.R. 656 and the President's proposal or your proposal. What are the differences, in your view?

Dr. **Bromley**. Well, to take a very minor difference first, between S. 272 and the bill we're considering here there really are very small differences. There is only the one section having to do with the protection of intellectual property, so there really is no major difference.

Mr. **Packard**. Is the protection adequate, in your judgment, in both pieces of legislation?

Dr. **Bromley**. No, I think that your bill here raises a very important issue, and it's one that merits consideration and thought because this is an area where as we move into the international marketplace and interact with our competitors abroad. The question of protection of intellectual property, particularly in the software area, becomes a significant one. That's an important point.

In the other Senate bill that is under consideration, S. 343, there are substantial differences because that bill does not have the coordination among the agencies that is in your bill and in S. 272 and in the President's initiative. Those are the primary differences.

Mr. **Packard**. Thank you. Does the President's initiative require the authorizing committee?

Dr. **Bromley**. Does it require it? No, sir.

Mr. **Packard**. So what role do you see this committee having in moving the President's initiative?

Dr. **Bromley**. I believe, sir, that if this committee could provide authorizations in a timely fashion and work with us and the Administration and with your colleagues in the appropriation committees and subcommittees to move forward an appropriation bill that maintains the cohesion that we're talking about in this initiative, then that would be enormously helpful.

Mr. **Packard**. If S. 272 and H.R. 656 were rolled into one, would the Administration be satisfied to see that one piece of legislation move?

Dr. **Bromley**. I would simply have to repeat the Administration's concerns that I mentioned earlier. First, we want to be sure that flexibility is maintained so that we don't freeze a rapidly moving technology for a five-year period when we really should be changing it on an annual basis. That's the prominent concern I have. A secondary concern is one about losing the hard-won coherence and integration that we have because of different actions by different subcommittees.

Mr. **Packard**. Last year there were disputes concerning the Department of Energy's involvement in the legislation, and that, I think, led to the demise of the legislation in the last session. Are there any conflicts in the Executive Branch at the present time concerning DOE's role, and is the Administration solidly behind the NSF taking the leading role versus DOE?

Dr. **Bromley**. I have spoken with Admiral James Watkins, the Secretary of Energy, who is a member of FCCSET, and I've been assured by him that the Department of Energy stands fully behind the commitment made in moving forward this initiative in the 1992 budget. In fact, the same is true of the Department of Defense, which is one of the other major players in this that falls in another—

Mr. **Packard**. So at the present time you see no major impediments from different agencies within the Government?

Dr. **Bromley**. I have been assured by the highest level personnel in all the agencies that they have, in good faith, signed off on this initiative and their participation in it.

Mr. **Packard**. It's a pleasure to have you with us, Dr. Bromley. It always is.

Dr. **Bromley**. Thank you.

Mr. **Packard**. Thank you very much, Mr. Chairman.

Mr. **Boucher**. The Chair thanks the gentleman and recognizes at this time the gentleman from Arkansas, Mr. Thornton.

Mr. **Thornton**. Thank you, Mr. Chairman.

It's a great pleasure to see you, Dr. Bromley.

Dr. **Bromley**. Thank you.

Mr. **Thornton**. I noticed in your testimony that you do think it is very important to have the Congressional support and endorsement of this program, and I would like to get a clearer understanding of what form that support might take.

Dr. **Bromley**. Well, in two sentences, sir, I think that it is very important for any of these major initiatives of major national importance to be carried forward with the highest possible degree of cooperation between the Administration and the Congress. I think that in your committee, in the authorizing committees,and in the appropriations committees we have work to do to make sure that we don't lose the kind of cohesion, the kind of integration that has been built in where each agency is by design playing a role that complements and adds to those of all the other agencies.

If agencies are moved out independent of any suggestion of this initiative, then we lose the whole coherence and would essentially have to start over again. Your support here, I think, is crucial to moving this in a reasonable fashion.

Mr. **Thornton**. Would you not agree that in addition to coherence among agencies, continuity over time is also a very important function for that?

Dr. **Bromley**. I would indeed, sir.

Mr. **Thornton**. I'm recalling the circumstances in which I found myself on this committee a few years ago where the President had eliminated the Office of Science Advisory to the President, and the idea was that it really wasn't needed to have that coherent and that continuing idea, and yet out of that came the initiative that there should be a statutory base for this in order to provide for continuity but also to provide for flexibility and for the advice to be given not only to the President but, as you so ably do, to this committee and to the Congress, and it just seems to me that statutory language does provide for continuity that may not be available without some written basis. Would you agree with that, sir?

Dr. **Bromley**. I would find it somewhat difficult to disagree with you in this particular instance. It demonstrates how ephemeral life really is.

[Laughter.]

Mr. **Thornton**. Well, I'm very glad that we have a statutory base for the science advisor to the President, and I hope that we'll give careful thought to that lesson from the past as we consider whether or not the support that Congress can give to this might indeed be in the form of legislation.

Dr. **Bromley**. Mr. Chairman, if I might just add a clarification, one of my staff has just reminded me that in fact North Carolina is a part of the network already, and so I'm delighted that we already have your constituents and colleagues firmly aboard.

Mr. **Boucher**. The Chair recognizes the gentleman from Maryland, Mr. Gilchrest.

Mr. **Gilchrest**. Thank you, Mr. Chairman.

Dr. Bromley, could you make a distinction between the thrust with the President's initiative for education and Senator Gore's idea that his plan or his initiative emphasized a much greater amount of—his plan proposed to do more for education than the President's plan? And the other question is, could you tell us how H.R. 656 in its present form, if it were passed, in your opinion, could hinder the creative natural flow of pure research?

Dr. **Bromley**. Could hinder?

Mr. **Gilchrest**. Hinder, yes.

Dr. **Bromley**. Let me respond to the first part of the question about education. I think frankly that there is a little misunderstanding here because in the document that we have sent forward, the Grand Challenges, we do in fact list education as one of the four major components of our program, and we have not amplified that in major sections of the document because, as I mentioned earlier, at the same time that this document was being prepared by a committee under the Federal Coordinating Council we were also doing one that was specifically on education, and in that document we cross reference this one.

Quite frankly, I don't see that there's any difference at all in the amount of potential educational impact, educational opportunity, in S. 272 and in the President's initiative. They really both recognize this as one of the extremely important areas but an area that has not been much explored yet. That's the important thing. An area where we have a tremendous opportunity that hasn't yet been realized. But there really is no difference between the two in that respect.

In terms of your second question, I frankly see no way in which H.R. 656 would hinder research and development at all. I think it would certainly move it forward without question.

Mr. **Gilchrest**. I'm trying to understand. The only real difference, then, as I see it, between the President's initiative and H.R. 656 is if we went through the statutory route, then there would be a—we would be covering the same ground again, and as we went through various committee hearings, the splintering up of the program could be caused?

Dr. **Bromley**. Two things, sir, if I may. The first is that the legislation is talking about taking a five-year look at the system and in a sense specifying a five-year program. My concern, and I raise it only as a concern, is that in an area where the technology is changing by orders of magnitude per year, I am concerned that we, in specifying a five-year program, may regret that as we, each year of that five, discover that we really would like to make some major changes in the program as we go along. That's the first concern.

The second concern is the one you mentioned, that of trying to maintain the coherence and integration in the various agencies that are being considered by different committees.

Mr. **Gilchrest**. Thank you, Dr. Bromley.

Thank you, Mr. Chairman.

Mr. **Boucher**. The Chair thanks the gentleman and recognizes the gentleman from Indiana, Mr. Roemer.

Mr. **Roemer**. Thank you, Mr. Chairman.

Good to see you again, Dr. Bromley, and your testimony last time before the committee was one of the first testimonies that I had heard, and it was very, very articulate and visionary, and I have to admit even with an advanced degree, I'm a little lost in some of the technical terms today, and my constituents are always interested in what I'm doing in my committee assignments, so please bear with my naivete in terms of some of the science.

If I could, what are the implications here in the supercomputers and the communications for trade and for our domestic industry? If you could answer specifically that. Also, did I hear you correctly in your payback numbers of someplace between $170 billion and—

Dr. **Bromley**. Yes, $170 billion and $500 billion.

Mr. **Roemer**. And then in terms of tying this all in, too, if you could give me specific examples in energy and environment and national security, that would be very helpful.

Dr. **Bromley**. Let me attempt to do that. First of all, in the environment—let me take that as an example—the major problem facing us at the present time is being able to make predictions of what climate will be like in particular regions of our Nation or of the globe over extended periods. There are currently in the world six independent so-called global circulation models that are run on very large supercomputers. When asked at this time what the future holds for the American Midwest, three of them tell us that it will be hotter and dryer, and three say it will be colder and wetter. On that basis, it is extraordinarily difficult to make reasonable policy—at least, policy that I would recommend to anybody.

Mr. **Roemer**. It's like our local weather stations, right?

Dr. **Bromley**. So what we recognize very early in the game is that in order to improve that situation, in order to be able to do better than just make predictions as we now can for global averages of various things like temperature and precipitation and so on, in order to be able to make it for a region like the American Midwest, we need these large factors of improvement in speed and memory capacity to do the calculations. Then we need the speed in information transfer to be able to take this flood of data that will be coming in from the sensors that we will both be flying in space and have on the ground.

As Senator Gore said, we're going to get the equivalent of the Library of Congress in 4.8 days from the one EOS platform alone in Mission to Planet Earth. To bring all that together, to allow us to discern patterns, to make predictions, we require absolutely the kind of power we're talking about here.

In the military, obviously, one of the areas that is still of importance to us is the design of advanced weaponry. Supercomputers got their birth there. We are very much interested in advanced aerodynamics, the design of new plane geometries. There you must have the supercomputers. But perhaps the most interesting example I can think of in the military is one that was demonstrated dramatically—but very few people know about it—in Desert Storm, and that is the fact that because our pilots and our tankers and our military personnel had in almost every case been able to run their mission—whether it was with a plane, with a tank, with a helicopter—had been able to run their mission in a simulator driven by a very powerful computer so that they could practice their run, see their target, see what the surroundings of the target looked like as they came in on it, that had an enormous impact on the rather dramatic successes that all of us witnessed on our televisions. That's the kind of thing that is going to be increasingly important in the military. It's the training that can be done with simulation of real world situations, making that available to everybody in the military rather than just to a few people who are going to fly shuttle flights, for example.

In energy, we have, again, a tremendous research program that requires the best possible computational tools and, more important, the best possible intercommunication among laboratories. We have in the national laboratories supported by the Department of Energy one of the world's major resources in terms of technology, know-how, but they're relatively isolated. What we need is to have a transparent connection between workers in the labs so that an individual sitting in Argonne could be working with someone in Oak Ridge or in Berkeley or in Brookhaven as easily as with the person next-door. That, too, is possible.

We can go through any of those particular fields you care to mention, but to answer the first part of your question about what's the impact on industry, the biggest impact, I believe, sir, will be on small industry, industries that hire fewer than 500 people. History has shown us over the last decade that those are the industries that have really produced the most innovative new products, services, they are the industries that have created a lion's share of the new jobs.

Up to now, they have had to do without the power that major companies have been able to afford. The major companies have their own supercomputers. We want to make the same kind of power available to the person with 20 employees who is trying to design something absolutely new that he would like to see designed in detail in all possible aspects but none of his computational capacity is up to the task. We would like him to be able to use his interface in his office just as easily as he picks up the telephone and get that capacity.

Mr. **Roemer**. Could you talk a little bit more about how that relates to education with the fiber optics coming into the classroom? And after both chairmen from North Carolina and Virginia, maybe we could do an experiment in Indiana on my schools to get that fiber optic going into Indiana school children.

Dr. **Bromley**. The technology, both hardware and software, sir, are now available, and demonstrations can be arranged that we'd be happy to do for you if you are interested in it, where a single fiber optic comes into the classroom and each student in the classroom has his own small terminal with a display panel and a keyboard. The software that's running on this system, depending on whatever subject you select, takes the student through whatever section of the material is appropriate for that time, that period in his exposure, and presents concepts in a very attractive, graphic fashion, then asks questions. If the youngster responds correctly, he gets a starburst and all sorts of things that reinforce it and comments saying, "Well done," and so on.

If he doesn't get it and doesn't understand it, then the system quietly takes him back through it and keeps doing it in slightly different ways until all at once the youngsters realize, "I understand it," and then the system gives them a tremendous award, and the important thing is that it's self-paced. It isn't the way it is in ordinary school rooms where if a kid misses it when the teacher presents it, the chances of the teacher knowing that he has missed it and coming back to fix that on the spot is very small. And having missed one thing, it's then much easier to miss the next one. And after you've missed a whole series of concepts, you're lost.

Mr. **Roemer**. How can I get an example either in person or by film or—

Dr. **Bromley**. If you would simply call my office, we will take care of arranging one for you.

Mr. **Roemer**. Great. How far away are we from commercially developing that and getting that into many of our schools?

Dr. **Bromley**. These systems are now commercially available. There are commercial companies that make these now available. The situation we face now is simply convincing school districts and States that this is a good investment at a time when investments in new hardware and software are difficult for obvious budgetary reasons.

Mr. **Roemer**. And finally, Dr. Bromley, your payback figure of $170 billion to $500 billion, what kind of time frame is that based on?

Dr. **Bromley**. Ten years.

Mr. ROEMER. Ten years. Thank you.

Mr. BOUCHER. The Chair thanks the gentleman and at this time would recognize the gentleman from California, Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman. I'd like to submit a statement for the record and ask unanimous consent for its inclusion.

Mr. BOUCHER. Without objection, so ordered.

[The prepared statement of Mr. Mineta follows:]

Mr. Chairman, I thank you for holding this joint hearing on the High-Performance Computing Act of 1991. I am very pleased to be an original cosponsor of the High-Performance Computing Act of 1991.

Mr. Chairman, in the 1990s and beyond, the clear challenge facing the United States is to create an environment that will foster and support our economic strength at home, and competitiveness abroad. The question is this: What must we do to ensure this strength and competitiveness.

For too long, we have failed to coordinate the efforts of Federal Agencies, Universities, National Laboratories, Researchers, and Educators. For too long we have ignored the importance of information sharing, and have failed to develop our information infrastructure of data bases, services, access mechanisms, and research facilities.

For America to regain its economic superiority, we must become more competitive. The High-Performance Computing Act is a vital part of the competitiveness solution.

Simply put, our competitiveness depends on the ability of the Federal Government to coordinate its efforts and make technology information more accessable to every public and private community that can benefit from this information infrastructure.

Mr. Chairman, The High-Performance Computing Act of 1991 is a critical part of this coordinated effort. Thank you.

Mr. MINETA. Dr. Bromley, we all admire your work and appreciate very, very much your efforts there. I'm wondering what is it about H.R. 656 that seems to give you heartburn about this whole issue about flexibility? What is it that you're afraid that this legislation, as you keep reiterating the word "inhibit"—inhibit what?

Dr. BROMLEY. Well, sir, we have taken a snapshot, if you will, of the computer and computational science of today, and this program that we present is the best program we can put together based on a five-year plan, knowing what we know today, making the decisions that are the most sensible ones based on that information for the next five years.

But we fully anticipate that a year from now we will have made enough progress so that we'll want to change those directions for the next four years or the next five, and each year as we go along we'll want to make substantial change in the program to take advantage of new things we've learned, new technology that's been developed, and so on. And I registered the concern that if we freeze-in a specific program over a five-year period, then it may well be difficult to make the changes that would be most appropriate in view of the technology and in view of the developments that have taken place. That's all.

Mr. MINETA. Well, it seems to me the legislation, though, does speak to that in the sense that it says, "Even though there shall be a five-year plan, the plan shall be resubmitted upon revision at least once every two years thereafter."

Dr. BROMLEY. That's in the right direction.

Mr. **Mineta**. Isn't that the kind of flexibility—I mean, you know, coming from Silicon Valley, I know that the obsolescence—you sort of work on a three-year obsolescence cycle—

Dr. **Bromley**. That's right.

Mr. **Mineta**.—so, you know, it is something that you sort of build in knowing that you're going to have to fine- tune it, even though it may be a five-year plan. Any plan, whether it's a capital improvement program when I was mayor for the city of San Jose or any other program, you have a five-year plan. As my dad said when we were in business, he said, "Plan your work and work your plan." I think that's what we're saying in this legislation, and to reiterate again what my colleague, Congressman Thornton, said, you have backsliding, and so what you need is a backstop to backsliders, and I think that's what this legislation does, is to keep that from becoming abandoned in terms of whatever good that comes out of this.

So it seems to me that flexibility is something that is inherent in this legislation and that there is recognition that, as you say, if there are orders of magnitude of change that that will be reflected in this and that we aren't engraving something in some marble for ever and ever.

Dr. **Bromley**. If I could—I understand your point, sir.

Mr. **Mineta**. Please.

Dr. **Bromley**. If I could just extend my remarks slightly, one of the things that your bill does is to define the roles of the agencies, and again, part of my concern is that it may well be that we will want to change the relative roles of agencies as we go forward. Now, if we can arrange to do these things, then my concern, of course, gets very much less.

Mr. **Mineta**. I wonder to what extent the change in the missions of those agencies become legislative and wouldn't be superseded in any event by that change rather than what's held here in H.R. 656?

Dr. **Bromley**. I would simply say, sir, that we would welcome the opportunity to work with you because I think we share the same goals here in great detail, and I am simply registering concerns that I have, that my colleagues have, having spent the last year pulling this together and trying to make all the pieces fit. We would be, as you can imagine, very distressed if something happened to take that apart before we really got off the mark.

Mr. **Mineta**. And when you spoke earlier, you used the phrase "critical mass," and I'm wondering what is the critical mass in this instance? Is that the fiscal year 1991 sum, fiscal year 1992, and what you envision by the fifth year, or are you talking about the technology within the industry, or—

Dr. **Bromley**. I'm talking about a different dimension, sir. What I'm talking about in critical mass is bringing together enough good people to work on a focused, directed program with a specific set of goals in mind so that their activities and their innovative skills are brought together and focused so that the sum is vastly greater than you would get just by adding up the individual efforts. It's in that sense rather than a financial or funding sense.

Mr. **Mineta**. In that sense, what about the—is the emphasis on the technology part of it, or to what extent do you bring along the human factors aspect of it as well?

Dr. **Bromley**. Your point is very well taken. The program has four components, sir. One has to do with the hardware where we want to maintain our leadership, the high- performance hardware itself; the second has to do with the software that makes it possible to communicate with that hardware; the third has to do with the networking that makes it possible for many people to get access to the system, use the software and hardware; and the last and certainly not least important is the people who will not only do the frontier development in computer science and engineering but also those people who will maintain and operate the systems and networks and make that power available to the users on demand. That's a very important part.

Mr. **Mineta**. And given those four factors, have you apportioned the amounts of money that you have envisioned here to those efforts?

Dr. **Bromley**. Yes, we have, sir.

Mr. **Mineta**. And roughly what would be the breakdown?

Dr. **Bromley**. Well, I don't have that specific number, but if you look on page 26 of the document, "The Grand Challenges," that I believe you have, pages 26 and 27 show you the breakdown, first of all, of activity among the participating agencies, and page 24 gives you a detailed breakdown which shows you down at the bottom of the page— you see, "Basic Research and Human Resources." If you look at the chart, 20 percent of the 1992 initiative is devoted specifically to that component, whereas, for example, high-performance computing systems—that's the hardware part—gets 25 percent, and so on. But the little pie chart in the inset on the bottom of page 24 probably is the most concise statement of how that breakdown is recommended.

Mr. **Mineta**. Now, is your only concern about this legislation this inhibition of flexibility?

Dr. **Bromley**. No, there are two. First is the potential inhibition of flexibility, and the second is that we have devoted an enormous amount of effort to getting all the agencies to agree to accept the specific responsibilities laid out in this table. If it should turn out that some of the major players here, in particular, report to different Congressional committees, and if the action of those committees was not coordinated, then we might find that it would be quite impossible to move forward with the kind of participation that we envisaged in putting the plan together. So I'm simply registering a concern and asking for your help to ensure that since the agencies within the Administration have signed off that this is what they want to do, are prepared to do, we need your help in making it possible for them to, in fact, do that.

Mr. **Mineta**. Very well. Dr. Bromley, I assume that your testimony here has been cleared by OMB prior to its submission.

Dr. **Bromley**. Indeed it has. Indeed it has.

Mr. **Mineta**. Well, I'm just going to make an editorial comment and let it go at that, and that is that we, I think— and especially the gentleman from California—at the time of your appointment were very happy that the President made your selection, and frankly I think a lot of times you're inhibited, your flexibility is inhibited, by idealogues somewhere else. Now, I know that sometimes for you your job is like shoveling sand against the tide, and I recognize that, and so I just want to commend you for what you're doing down there, and I know that our committee will continue to work with you to make sure that we do things that are in the best interest of the country regardless of idealogues. Thank you very much, Doctor.

Dr. **Bromley**. Thank you, sir.

Mr. **Mineta**. Thank you, Mr. Chairman.

Mr. **Boucher**. The Chair thanks the gentleman and recognizes once again the gentleman from California, Mr. Packard.

Mr. **Packard**. I apologize for coming back, but the question was asked Senator Gore, and I think it reflects the concern certainly on this side of the aisle, one of the concerns of the legislation, and that is that will the Government end up owning and operating in perpetuity a system, wonderful as it may be. And his answer was that in the initial stage they will develop and operate and own, but the goal is to have a transition to the private sector.

In your strategy, in your proposal, it mentions that the Government would become a prototype user for early commercial high-performance computing and communication products. You have inserted that transition, I believe, conceptually into your proposal. How can we ensure that that transition will take place with legislation?

Dr. **Bromley**. Let me begin, if I may, sir, by just reviewing what I see as the transition. At the beginning, we're going to start out with a series of major pieces of hardware—supercomputers, high-performance computers—that are presently owned by educational institutions, by the Federal Government, by national laboratories, and we're going to tie those together with a network of fibers that are owned by the common carriers—by AT&T, by Sprint, by MCI, whomever. The Government isn't going to own that at all. The Government will own some of the hardware that's on the system.

Mr. **Packard**. The high-end switches and the supercomputers?

Dr. **Bromley**. That's right. That's correct. But as we move forward, we already see these organizations like Advanced Network Services being crafted by the private sector, ready to move in to expand the network, first of all, so that more people have access to this hardware that is already available. I would anticipate fully that within a very short time we're going to find private sector organizations buying in, providing pieces of major hardware that will be connected into the network. But I emphasize that the network we're talking about here, the National Research and Education Network, is not the network that we envisage as coming hopefully toward the end of this decade. That one is one that we would see completely put together by private sector organizations.

We would certainly want to have interconnects so that that particular system could talk to our test bed. That's really what the NREN is—a test bed to figure out how to make all these things work so that when they're transparent to the user, so that the guy sitting down in his office at his work station has a particular problem, we want to have the system sufficiently smart so that, when it sees what this problem is, it will simply take the problem and direct it to the appropriate hardware somewhere on the net. It could be on the West Coast, the East Coast. It could be anywhere, and you don't want to know what piece of hardware is doing your work for you because when it's finished, something sends you back your answer, and that's all you need to know.

Now, as we progress, I see that system probably continuing its role as a test bed for the really advanced frontiers of computational science, attacking the grand challenges, and so on. In parallel with this, the public utility that will draw on this NREN for its architecture, for a lot of its software, and we will interconnect them so that on some appropriate basis—there will obviously be regulatory questions, just as in the telephone system—but on some appropriate basis, just as you pay for your telephone, you pay for connection to a system that has a certain capability, and you pay appropriately to whatever the capability is.

Mr. PACKARD. Thank you very much.

Mr. BOUCHER. Dr. Bromley, we greatly appreciate your attendance here this morning and your lengthy and informative testimony, and I want to commend you once again on the foresight that you've demonstrated in bringing this initiative forward. This subcommittee will look forward to working very closely with you as the initiative advances, and again I would underscore our willingness to receive from you any recommendations that you now have or will have over the next several weeks or months in terms of how this legislation might be restructured to resolve the problems with potential inflexibility that you've demonstrated and stated here today.

Dr. BROMLEY. I would thank you, Mr. Chairman, and if I might, first of all, say that my colleagues will welcome the opportunity to work with you because, as I say, we share common goals. Secondly, if I might in closing take the opportunity again, Mr. Chairman, to express to you my appreciation of the remarkable job that has been done by the agency representatives who have worked long and hard during this past year in putting this document together and in putting the program together. It does represent, I believe, a new high in cooperation and mutual trust across the whole spectrum of the agencies. Thank you, sir.

Mr. BOUCHER. Thank you very much, Dr. Bromley.

Mr. BOUCHER. We will welcome now our third panel of the morning, and I would ask each of these panelists to come forward now: Dr. Kenneth King, the President of EDUCOM; Dr. Glenn Ricart, the Director of SURANET; Mr. Jim Young, the Vice President for Regulation and Industrial Relations for Bell Atlantic; Dr. George Johnston, Research Scientist, the Plasma Fusion Center for MIT; and Dr. Stewart Personick, the Assistant Vice President for Information Networking as Bell Communications Research.

Gentlemen, we welcome you here this morning. Without objection, your written statements will be made a part of the record. The subcommittee has a five-minute rule with regard to opening statements, and in view of the hour, I would ask the panelists to please adhere to that rule and summarize your testimony within that five-minute period, and the subcommittee will withhold questions until all of the panelists have delivered their opening statements.

We welcome you here this morning, and, Dr. King, let's begin with you. We'd be happy to hear your testimony.

STATEMENT OF KENNETH M. KING, PRESIDENT, EDUCOM, WASHINGTON, D.C.

Dr. KING. Mr. Boucher and Mr. Valentine, it is a pleasure for me to respond to your invitation to testify before your subcommittees this morning.

I represent EDUCOM, an association of over 600 American colleges and universities working on the goals of creating a national information technology infrastructure and using information technology to improve intellectual productivity and teaching and learning. I also represent the Partnership for the National Research and Education Network, a group of associations, organizations, and corporations which are supporting the creation of a national research and education network—NREN. The Partnership recently forwarded to your committee an NREN policy framework statement, and I am enclosing a copy of that statement with my testimony.

Since you have a number of excellent witnesses this morning, my remarks will be confined to the areas in which we have been most involved, which is the National Research and Education Network. There are four key points that I would like to make.

One is that stable funding over the next five years is critical to reach the ambitious objectives and goals of this effort and to leverage the commitment in investment of the higher education community. The higher education community is going to have to spend an enormous amount of money to create the local area networking connections that connect its faculty and students to this national research and education network in anticipation of its benefits, and therefore suitable legislation which ensures that something will actually happen over five years I think could be very beneficial in encouraging that commitment.

Second, the bill needs an explicit recognition of the fact that the network is being created by a partnership between Government, industry, and education, and these partners all need an effective voice in the development and management of the national research and education network, and the bill doesn't explicitly provide for that at the moment. Third, our Nation's libraries have a critical role to play in the National Research and Education Network both as providers of electronic information and as access points for the users, and they need to be fully involved as partners in this effort; and fourth, it is important to provide access to commercial information services to this network and remember that the ultimate aim of the NREN is to pave the way for the electronic national information infrastructure which will form the communications base for our economy in the 21st century.

[The prepared statement of Dr. King follows:]

Recommendations on H.R. 656
The High Performance Computing Act of 1991

Statement of
Dr. Kenneth M. King, President, EDUCOM
to the
Subcommittees on Science, and Technology and Competitiveness
United States House of Representatives
March 7, 1991

SUMMARY

Mr. Boucher and Mr. Valentine, it is a pleasure for me to respond to your invitation to testify before your subcommittees this morning. I represent EDUCOM, an association of over six hundred American colleges and universities working on the goals of creating a national information technology infrastructure and using information technology to improve intellectual productivity and teaching and learning. I also represent the Partnership for the National Research and Education Network, a group of associations, organizations and corporations which are supporting the creation of a National Research and Education Network (NREN). The Partnership recently forwarded to your committee an NREN Policy Framework statement and I am enclosing a copy of that document with my testimony.

The bill before you, H.R. 656, reflects more than five years of study by your committee staff, by a number of federal agencies, and by external advisory groups such as the National Academy of Sciences. All of these studies have validated the urgent need for an advanced computer network to support scientific research, education, and commerce, and in addition have identified the need for a coordinated high performance computing research program that reaches beyond the NREN to include software and hardware development and related educational and human resources elements. Since you have a number of excellent witnesses this morning, my remarks will be confined to the area in which we have been most involved, which is the NREN.

The creation of the NREN is an ambitious undertaking. It requires high technology, some of which is not yet developed; a nationwide operational infrastructure of advanced communications facilities; and a working partnership of many organizations and individuals from government, education and industry. The ultimate aim of the NREN is to pave the way for the electronic national information infrastructure which will form the communications base for our economy in the 21st Century.

EDUCOM has been active in addressing the many issues involved in creation of the NREN for several years, commencing with our testimony before this committee in 1987. Since 1988, we have sponsored an annual National NET Conference here in Washington, to be held on March 21-22 this year, which brings together experts from public and private sector organizations who are working on the network.

Many important technical and operational aspects of the NREN have already been demonstrated and proven in the network we have today known as NSFNET. In fact, the NSFNET currently connects more than five hundred research and education sites, embracing more than a million individuals, and continues to grow. The success of NSFNET has encouraged Dr. Bromley and the Federal Network Council to identify it as the "Interim NREN" in their recent High Performance Computing and Communications Program announcement.

In my summary statement, I would like to focus on a short number of critical issues which I believe should be dealt with in the pending legislation.

- **Stable Funding.** The Administration has proposed funding for the NREN for FY92 in the amount of $92 million, distributed among a number of agency budgets. This level of funding is consistent with previous agency planning, and with the cost experience gained with NSFNET. Additional funds would be helpful, but it is essential that at least this level of funding be assured in order to guarantee that the critical federal role of catalyzing university and private sector contributions to the NREN is realized.

- **Effective Public/Private Sector Partnership.** The rapid progress that has been made in the last several years toward a national network is in large measure the result of cooperative efforts between and among a large number of groups, including federal agencies, universities, regional and state networks, and private sector computer and communications companies. It is estimated that investments by higher education and industry in NSFNET over the last four years have exceeded federal expenditures by nearly ten times.

The bill before you, H.R. 656, makes no explicit provision for a continuation of these partnership roles, nor does it require the Executive Branch to give universities, libraries and industry an effective voice in the development and management of the NREN. Our recommendation is that section 6 of the bill be amended to establish a National Network Council, with participation from the several constituencies involved with the NREN, and that the policy recommendations of the Council should be binding with respect to management of the NREN, within the limits of its authorizing and appropriations legislation.

- **NREN Use by Libraries.** In the long run, the value of the NREN will be measured in the contributions to research and education made possible by network access to information resources. Our nation's libraries have a critical role to play in the NREN, both as providers of electronic information and as access points for their users. EDUCOM, along with the Association of Research Libraries and CAUSE, recently formed the Coalition for Networked Information (CNI). The Coalition, which has more than one hundred and twenty library, university, government and industry members, has a special focus on the provision of electronic information resources on the NREN. This organization is addressing the full range of issues - from securing information resources on the network to protection of copyright - through the work of its committees and task forces.

- **Commercial Services.** An important role of the NREN is to leverage the creativity and energy of the research, education and library communities to define and demonstrate new network based information services, many of which may have commercial potential.and can be picked up and supported by private firms as part of creating the national information technology infrastructure. In order to facilitate this, NREN policy should enable the millions of information intensive users on the Interim NREN and the gigabit NREN to access a variety of information services and networks, including those operated within the private sector.

In developing the NREN, it will be important not to create excessive expectations. The NREN should provide selected access that proves feasibility and leads to the creation of a commercial infrastructure that can support universal access. The plan which has been developed by Dr. Bromley and his staff is an excellent one. It provides that over the next three to five years, the NREN will be extended to reach one to two thousand research, education and library sites, and that the performance of the network for research applications will be upgraded to support data and image transfers at gigabit speeds. If we focus on these goals, and work our way through a multitude of technical and operational issues in the process, then the success of the NREN will fully support its extension to broader uses in the years to follow.

TESTIMONY SUBMITTED FOR THE RECORD

Introduction. The comments which follow are keyed to the questions posed in the charter for the High Performance Computing bill hearing dated February 26, 1991.

Scope and Focus of H.R. 656. *Does the administrative framework established by the bill for planning, implementing and monitoring the various parts of the high performance computing program constitute the most effective approach?*

As discussed in the hearing charter, the legislative initiatives in HPC and a related effort planned by the Administration share many common goals and features, having developed in parallel since a 1986 congressionally mandated study on advanced computer networks. It is highly desirable that the minor differences between the two approaches be eliminated during the current legislative process in order to ensure that all parties involved in development of the NREN - federal agencies, colleges and universities, libraries and private sector companies - may have a common understanding of program goals, objectives and funding.

The scope of the NREN has expanded substantially since the original OSTP report in 1987. In particular, there is a much greater awareness now of the potential uses of the network in teaching and learning at all levels, and of the value of libraries as both providers of information as well as sources of access to the network for their users. The members of the Partnership for the NREN believe that the Congress should adopt a broad set of principles to guide the development of the NREN, rather than a detailed and prescriptive list of legislative directives. Based on the experiences of a wide variety of university, library and industry users of NSFNET over the last several years, a proposed NREN Policy Framework was developed by the Partnership and forwarded to this and other relevant Congressional committees in January, 1991. A copy of the statement and its covering letter listing the members of the Partnership is appended. Although the purposes of the NREN outlined in the Policy Framework are generally consistent with Section 2, Findings and Purpose, of H.R. 656, there are differences. Most notable is the lack of any mention of the partnership roles of libraries or colleges and universities in carrying out the purposes of the NREN. Nor does this section contain any mention of the value of the NREN to teaching and learning beyond narrowly defined research and scientific goals.

Issues Related to NREN. (1) *What should the management structure of the NREN be in order to adequately represent the interests of federal agencies, regional networks, network users and the communications and computer industries?*

The general strategy that has guided the development of NSFNET, now renamed the Interim NREN, has been to expand user access to the network while simultaneously upgrading its performance using currently available commercial technology and preparing for gigabit speeds later in the 1990's. This strategy has been successful only because of a unique approach to network management in which major commercial entities - MCI and IBM; a major state network - MERIT; and dozens of regional, state and campus networks have cooperated to achieve both goals simultaneously.

The key to the success of the NREN will be the development of a distributed management structure which deals with problems and issues as close to the network user as possible. Some of that structure is in place today, but much remains to be done. The principal challenges include: (a) ensuring federal support for a fifty state backbone which provides high quality access to regional and state networks; (b) strengthening and broadening the service offerings and access points of the state and regional networks; (c) upgrading and expanding the local networks at campus sites, government laboratories, libraries, and private research locations; and (d) facilitating the connection of the computers which will provide database and supercomputing applications for network users.

H.R. 656, reflecting its legislative origins over three years ago, has a narrow federal focus. This should be expanded to include all of the partnership interests which will be necessary for the fully developed NREN. Specifically, a National Network Council, with the power to set network policy and operating guidelines, should be included in the markup of H.R. 656. The membership of the Council should reflect the broad interests of network developers, providers, managers and users. The Congress may wish to consider, either now or at a later date, whether the importance of the NREN to national goals in research and education justifies the creation of a special entity to oversee the network, as described in the NREN Policy Framework.

(2) *What are the barriers (technical, financial, markets, political) with respect to the transition to commercial network services? Are special management strategies required for NREN to achieve commercialization?*

Section 6 (c) (7) of H.R.656 provides that "[The NREN shall] be phased into commercial operation as commercial networks can meet the needs of American researchers and educators." This provision of the bill has been misinterpreted as implying that the Interim NREN and the initial gigabit NREN do not have a commercial component. **All of the transmission facilities for the Interim NREN and the regional and state networks which are a part of the Interim NREN are commercially provided. Nearly all of the packet switches and network software in use in the Interim NREN today are commercial products. Well over half, and perhaps as much as three-quarters of the federal, state and local funds expended on the Interim NREN and related research and education networks are paid to private sector firms through standard procurement processes.**

The existence of this section of H.R. 656 is traceable to the predominantly federal character of research networks which were developed in the 1970's. The intent of the legislative language is to ensure that technology developed for the NREN can be shared with and incorporated into the advanced communications networks for the 21st Century which are currently under development by private sector firms. This is no longer a serious concern. The Interim NREN is based on readily available commercial technology, and a majority of the NREN research projects being conducted by DARPA and NSF are using commercial fiber optic transmission facilities. Over the past decade, and especially since telephone industry deregulation, there has been a sea change in attitudes toward advanced communications technology among leading commercial firms. Today, large investments are being made in broadband transmission facilities, with many gigabit fiber optic links already in operation. On a worldwide basis, computer and communications firms are developing and adapting their products to create large scale networks capable of instantaneous transmission of voice, data and images. The planning and engineering of the NREN can assume that such high performance commercial facilities will be an integral part of the network structure.

The working partnership among government, industry and education which has been established in the building of NSFNET is added evidence that advanced network technology developed for the NREN will find its way into commercial products and services rapidly and effectively.

(3) Given the nature of R&D and the long lead time required to achieve commercially applicable communications and computer standards, how might the products of NREN related R&D become future protocol standards? What management strategies are required to make it happen?

The extremely rapid progress experienced in building NSFNET over the last several years is a result in significant measure of the cooperative approach to standards development which prevails in the Internet community of which NSFNET is a part. Under the guidance of the Internet Activities Board, a large number of technical experts from industry, higher education, and government laboratories have worked together to extend the packet switched network protocols known as TCP/IP. No Internet standard is adopted until an implementation of it has been demonstrated under actual network operating conditions. New standards have been developed and put into use in as short a time as six months, and many are completed within a year.

The techniques used within the Internet are now being adopted in other standards bodies, and the Internet standards are being brought into alignment with complementary international efforts such as the ISO packet standards.

It is essential that the standards approach now used for the Internet be adapted and adopted for the NREN. The pertinent language in Section 9 of H.R. 656 does not accomplish this and should be amended to make explicit provision for the authority of the Internet Activities Board, or a comparable successor organization, to set standards for the NREN provided that they continue to be developed on a cooperative basis among the NREN participating organizations as they are today.

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January 25, 1991

The Honorable George Brown, Jr., Chairman
House Science, Space, and Technology Committee

The Honorable Robert Walker
House Science, Space, and Technology Committee

Dear Mr. Brown and Mr. Walker,

The Partnership for the National Research and Education Network is writing to request your support of legislation for a high capacity national computer network to serve a broad range of research and education purposes. The Partnership, whose current members are listed below, encompasses a number of education, library and computing organizations and associations.

The NREN will be critical to increasing the nation's research productivity and economic competitiveness through rapid diffusion of research and educational technology that meets national needs. For the past several years, a number of federal agencies, several state and regional network organizations, and many colleges and universities have been working to bring the benefits of high performance computing and advanced networks to their instruction and research programs. Considerable progress has been made, with hundreds of campuses and research sites already connected to existing low to medium speed networks. The initial successes and potential for far greater positive impact on the nation's research capability, as well as improvements in educational productivity, call for the stimulus of federal investment.

To realize these objectives, NREN legislation must incorporate the key points listed on the attachment. In summary, these points are based on a conviction by the members of the NREN Partnership that:

- Creation of a federal, state and local networking partnership, with contributions from all levels, will be essential to the success of the network;
- Education in its broadest sense complements established research objectives as a reason for development of the NREN;
- All involved constituencies of the NREN must have a voice in the development of network policy.
- All fifty states should be provided high capacity access to the network.

It is anticipated that the President will include a proposal on the NREN in his FY92 budget; however, there are a number of issues unaddressed by current Administration plans that we believe require legislative action by the Congress. In addition, although Congressional hearings were held last year, and S.1067 (The High Performance Computing Act of 1990) passed the Senate, the bill did not include many of the provisions we believe are essential to the success of the NREN.

We look forward to congressional hearings in this session on bills incorporating these points and to working with you on this important legislation.

Sincerely,

Kenneth M. King

Kenneth M. King
President

cc: Members of the House Science, Space, and Technology Committee

Members of the Partnership for the National Research and Education Network

Advanced Network & Services Incorporated
American Association of Law Libraries
American Association of State Colleges & Universities
American Council on Education
American Library Association
Apple Computer Corporation
Association of American Universities
Association of Research Libraries
AT&T
Bell Atlantic
CAUSE
Chief Officers of State Library Agencies
Coalition for Networked Information
Computing Research Association
Corporation for Research and Educational Networking
EDUCOM
The Federation of American Research Networks
IBM/Academic Information Systems
MCI Corporation
National Association of State Universities and Land-Grant Colleges
Special Libraries Association

Mr. Boucher. Thank you, Dr. King, both for the information you've provided and for the brevity of it.

We now would like to recognize Dr. Ricart, and we welcome you and will be glad to hear your comments.

STATEMENT OF GLENN RICART, DIRECTOR, SURANET, WASHINGTON, D.C.

Dr. Ricart. Thank you, Mr. Boucher.

In 1983, I and about two dozen of my colleagues got together to discuss a supercomputer for the southeast, and we were thinking about what the strategy ought to be, and after two days of consideration we came to the conclusion that supercomputers would happen, but it would be much more difficult to bring access to those supercomputers and to the resources that those supercomputers would make available to the southeast. What we really needed was a research and education network in the southeast. We started that network, SURAnet, it's a project of the Southeastern University's Research Association, and today it interconnects more than 100 institutions of research and education in the southeast.

That's not my only vantage point. I'm also responsible for academic computing at the Nation's 11th largest campus, the University of Maryland at College Park, where I also conduct research and teach as a faculty member in computer science. My course in computer architecture is carried Nation-wide over satellite. I've also been elected this year president of FARNET, an association of more than 30 American computer networks serving research and education.

The proposed NREN will make research in the United States much more productive for four reasons that I've put in more detail in my written testimony, but basically by providing more effective research we can build on the work of others more effectively; second, we can collaborate more effectively; third, we can leverage unique resources such as the continuous electron beam accelerator facility being built in Hampton Roads; and fourth, these first three will lead to a democratization of science by making these kinds of resources, the information, the collaboration, and the access to facilities like CEBAF available Nation-wide to small colleges as well as large colleges like the University of Maryland.

So far I've been speaking of research, but all of these things are of tremendous benefit to education as well, from kindergarten through higher education and on into lifelong learning. I also predict that the NREN will be the most powerful technology transfer mechanism devised in my lifetime because it permits Government, education, and industry to look over each other's shoulders effectively.

With the vast majority of research, education, and technology transfer occurring in U.S. colleges, universities, and other institutions of education, the NREN should be highly influenced by these institutions. I believe that H.R. 656 as currently drafted leaves too much responsibility to the Federal agencies to interpret the needs and priorities of the research and education communities. For example, the section 701(a) National High-Performance Computing Plan never mentions any involvement by the research and education communities the plan will presumably serve. In section 6(f) of the bill, the Council is charged with execution of the NREN, but again without any note of involvement from the communities that the NREN is intended to serve. The existing regional and State networks which are governed by the research and education communities appear to have been forgotten. Libraries are not mentioned. I believe we need a more direct voice, and I am suggesting in my written testimony some changes that would recognize a specific role for research and education in the national research and education network.

Existing regional and State networks, most of which are associated with research and education organizations, continue to be the ideal means of providing an integrated and scholarly NREN service. Nevertheless, an increasingly large number of components of that service can and will be commercially provided. Over 50 percent of the expenditures in today's computer networks are spent on commercial services, and I'm very glad to see companies like Advanced Network Services providing additional services that can also be commercially provided. At the same time the commercialization of the transport services is occurring, the regional and State networking groups will provide higher, more academic and scholarly based services. The regional and State networks have a significant role also to play in enlarging access to include groups that may be difficult or uneconomical for commercial enterprises to serve.

I support all of the clauses in H.R. 656 that call for a progressive and phased increase in the use of commercial services at the same time I call for continued research and education guidance of the NREN and integration by the regional and State networks.

Computer-based communications and information is more than likely the fastest growth industry in the United States today. Last year at the University of Maryland at College Park, we passed a milestone. More of our communications system was used for passing computer data traffic than used for passing voice traffic, and the computer communications component continues to grow. A competent NREN can leverage this trend nationally and bring benefits to the Nation. Thank you.

[The prepared statement of Dr. Ricart follows:]

Testimony of Dr. Glenn Ricart before the House Science Committee's Subcommittee on Science and its Subcommittee on Technology and Competitiveness holding a joint hearing on H.R. 656, the High-Performance Computing Act on March 7, 1991 from 9:30 a.m. to 1:00 p.m, 2318 Rayburn House Office Building

Principal Investigator, SURAnet

It is a distinct pleasure to be here today to support H.R. 656 and particularly section 6, which would establish the National Research and Education Network.

In 1983, I was one of two dozen university representatives plotting how we might get a supercomputer in the Southeastern United States. After a two day meeting, we left with a firm conviction that it would be much more important to construct a computer network instead. That computer network, SURAnet, became the first part of the NSFnet to become operational. Today it interconnects approximately 100 research and education institutions. This project is coordinated through theSoutheastern Universities Research Association which has 40 members.

This isn't my only vantage point. I am responsible for academic computing at the nation's eleventh largest campus—the University of Maryland at College Park—where I also conduct research and teach as a faculty member in Computer Science. My course on computer architecture is carried nationwide by satellite.

And, I am president of FARNET—a federation of more than 30 American computer networks serving research and education.

~~[illegible]~~

The United States spends more money on research and development than any country in the world. But on a per capita basis, we rank behind several of our competitors. We must make efficient use of our research dollars. The proposed National Research and Education Network (NREN) can help provide that efficiency in several ways:

> First, research is a process of reaching ever higher by standing on each other's shoulders. My research is built upon and adds to the research work of others. Others build upon my ideas. The height and value of the work I do depends upon the height of the platform at which I start. A properly constructed NREN will give me access to both more varied and more timely research results than I can now find printed (and slowly growing obsolete) on the library shelves. From the higher platform the NREN will give us, we will be better able to conduct more breakthrough research that can solve American problems.
>
> Second, research is a process aided by interaction with my peers. When I come up with a real boner of an idea, sometimes someone has to tell me about it. But when I come up with a really good idea, the enthusiasm that is generated spurs me onward. Today's computer networks provide primitive electronic mail and conferencing mechanisms that have already proven their value in research productivity by filling a role that conferences, telephones, and journals can't touch. I believe that NREN will provide dramatically new and exciting opportunities to collaborate.
>
> Third, we need to share our unique research resources. For example, the Continuous Electron Beam Accelerator Facility (CEBAF) now being constructed by SURA near Hampton Roads, Virginia, will deliver a tremendous amount of scientific data. With SURAnet enhanced to the gigabit speeds envisioned by the NREN, this accelerator could be ~~controlled~~ accessed by scientists located at institutions located in the Southeast and across the

country. They could see their CEBAF results based on results at their location in real time. This will provide tremendous leverage for the investment in CEBAF.

The first three benefits will give rise to a fourth: the democratization of science. The same information access, peer interaction, and CEBAF data made available to a University of Maryland and its $100 million research program can just as well be delivered to a deserving faculty member at a small, struggling college.

Fifth, there will be positive effects I can't forsee. In my 20 years of computer networking, I've never been able to overestimate what the future can bring.

So far I have been speaking of research, but all of these things are of tremendous benefit to education as well—from kindergarten through higher education and on into lifelong continuing education. The NREN that gives me access to varied and timely research results provides a fascinating and comprehensive information source for pre-schoolers through continuing education. The NREN that helps me interact with my peers can also give fourth graders interested in science a pipeline to other fourth graders doing similar experiments in other States. The fact that it is the same NREN that is used in higher education means that those fourth-graders might also find a sympathetic professor of life sciences who would be willing to interact with them over the NREN. The NREN that delivers online CEBAF data to professors can also deliver CEBAF data to university students who can explore it using their own intuition and theories.

In addition to research and education, the NREN can transfer technology to United States industry. We've all struggled with finding mechanisms for transferring lab and theory results to the small and large businesses that need them. But how better could we do it than by letting them watch over our shoulders as we interact with each other and share data over the NREN? I predict that the NREN will be the most powerful technology transfer mechanism devised in my lifetime.

If I sound optimistic, it is because I am. The usage on the computer networks we now have has grown by an average of 15% per month, compounded, over the last four years. This represents an increase by a factor of 5 every year. About half of that growth rate is new users. The other half represents increasing use by those already connected.

The NREN will be a stimulating and exciting catalyst to U.S. research, education, and technology transfer to industry. H.R. 656 and S. 272 and the funding they authorize are vital to the creation of the NREN. The benefits will flow not so much to individual researchers and students as to the United States and its ability to innovate and compete.

Management Structure

With the vast majority of research, education, and technology transfer occuring in U.S. colleges, universities, and other institutions of education, the NREN should be highly influenced by these institutions. I believe that H.R. 656 as currently drafted leaves too much responsibility to the federal agencies to interpret the needs and priorities of the research and education communities for us. For example, the section 701(a) National High-Performance Computing Plan never mentions any involvement by the research and education communities the plan will presumeably serve. In section 6(f) of the bill, the Council is charged with execution of the NREN, but again without any note of involvement from the communities the NREN is intended to serve. The existing regional and state networks which are governed by the research and education communities appear to have been forgotten. Libraries are not mentioned. We need a more direct voice. I am suggesting in my written testimony some changes that would recognize a specific role for the research and education community in the National Research and Education Network.

Transition to Commercial Services

The National Research Council, in its 198~~8~~9 report on Information Technology and the Conduct of Research, has made a firm recommendation that control of information technology be put in the hands of its users. To carry this out, the NREN should be guided and designed by and for the research and education communities it serves. The existing regional and State networks, most of which are associated with research and education organizations, continue to be the ideal means of providing an integrated and scholarly NREN service. Nevertheless, an increasingly large number of components of that service can and will be commercially provided.

For example, today I estimate that well over 50% of regional computer networking expenditures represent the procurement of commercial services, and commercial companies are expanding the range of services they provide. In the future, an increasing percentage of present services can be procured commercially. I applaud the efforts of companies such as Advanced Network and Services, Performance Systems International, and UUNET, Inc. to expand their repertoire of NREN-related services. I also expect the established communications carriers to discover that they can and do play leading roles as well.

These commercial suppliers will have substantial markets outside the NREN proper. I expect flat-out commercial uses with no tie to research or education to be substantial markets for commercial service providers.

At the same time, commercialization of transport services will free the regional and state networking groups to provide higher level academically-based services. For example, I expect regional and state networks to arrange for the on-line delivery of experimental data from unique scientific resources, such as the Continuous Electron Beam Accelerator Facility. Inter-institutional databases of research reports, calendars of seminars and colloquia, and databases of inventions and patents will become important information components of the regional and State NREN organizations.

The regional and state networks also have a significant role in enlarging access to include groups that may be uneconomical for commercial enterprises to serve. Community colleges, libraries, and public schools usually have academically-defined needs that the regional and state networks can effectively address.

I support the clauses in H.R. 656 that call for a progressive and phased increase in the use of commercial services at the same time I call for continued research and education guidance and integration by the regional and state networks.

The Role of Emerging Commercial Communications Standards

The networking community recognizes that increased levels of network service will require the adoption of contemporary communications standards. The first test for new standards is improved functionality. The second test is cost-effective availability. The third test is conformance with network-wide interoperability. The community is prepared to embrace with open arms those portions of the OSI protocols, Integrated Services Digital Networking, and Synchronous Optical Network Standards that meet these tests and enhance and improve research and education networking. It is only by following such standards that we can achieve the benefits of competitive commercial services.

Regional Networks Representation

As a principal investigator of a regional network and as the President of FARNET, I believe that the National Science Foundation understands the value of regional network participation in the NREN process and will strengthen this relationship. H.R. 656 does not at present recognize the significant contributions regional and state networks could provide to the deliberations of the Council or in the creation of the Plan. The changes to H.R.656 I have proposed calling for the involvement of the research and education community in the NREN would give the regional and state networks appropriate avenues for input on the NREN.

Summary

Computer-based communications and information is more than likely the fastest growth industry in the United States today. Last year at the University of Maryland College Park we passed a milestone. More of our campus communications system was used for computer data than for voice. And the computer communications component continues to grow. A competent NREN can leverage this trend nationally and bring benefits to the entire country.

Section 4 (b). Page 5 line 4, add after "departments"

4 ments and the researchers they support shall procure prototype or early production models of

Rationale: The university community has always been an important testbed for new computing technology, and the Act ought to recognize and encourage this role.

Section 5's Section 701(a)(5)(A). Page 7 line 24, change "run" to "sponsored"

24 works ~~run~~ sponsored by the agencies and departments;

Rationale: We want to encourage agencies and departments to cost-effectively use existing academic and industrial networking where appropriate.

Following Section 5's Section 701(a)(5). Page 9 after line 8

8.1 "(K) add value to the National Research and Education Network (see Section 6) by sponsoring network information and computing resources and by sponsoring access for appropriate uses by the education community.

Rationale: The agencies and departments should plan to work together to be contributors to the quality and value of the NREN. This responsibility should extend beyond the National Science Foundation (covered in section 7) to the other agencies involved. This clause gives the other federal agencies a direct role in the success of the NREN.

Following Section 5's Section 701(a)(6). Page 9 after line 14

14 plan consistent with the Plan.

14.1 "(7) The nation's higher education and research community shall be a full partner in the processes to create and update the Plan because of the community's key role in research for and utilization of high performance computing and networking.

Rationale: If the High Performance Computing Act is to have a catalytic effect on the nation's research and educational efforts, those on the front lines must be intimately involved in crafting the plans.

Following Section 6(c)(1). Page 13 line 14

14.1 (0) endeavor to promote excellence and productivity in research and education by being responsive to the education and research communities and their expressed needs;

Rationale: The other clauses assign a role to everyone in the NREN except for the research and education communities themselves.

Amend Section 6(f)(1). Page 15 line 5

5 Act of 1976, as added by section 5 of this Act, shall, with guidance from the research and education communities and the regional and state academic networks—

Rationale: The Federal Agencies and the Council should be guided by the communities the network serves.

Alternatively, the NREN could be managed by a National Network Council which is more broadly constituted than the proposed federal Council as suggested by Dr. Ken King's testimony.

Amend Section 6(f)(1)(A). Page 15 line 7

7 Network responsive to the needs of America's researchers and educators.

Rationale: The primary source of the goals, strategy, and priorities ought to be the improvement of American research and education.

Amend Section 6(f)(1)(B). Page 15 line 9

9 partments sponsoring and implementing the Network;

Rationale: Federal agencies may wish to sponsor as well as directly implement sections of the network

Mr. BOUCHER. The Chair thanks the gentleman and would recognize now Mr. Young.

STATEMENT OF JIM YOUNG, VICE PRESIDENT FOR REGULATION AND INDUSTRIAL RELATIONS, BELL ATLANTIC, ARLINGTON, VIRGINIA

Mr. YOUNG. Thank you, Mr. Chairman.

Good afternoon. My name is Jim Young, and I'm Bell Atlantic's Vice President for Regulatory and Industrial Relations. I'd like to thank Chairman Boucher and Chairman Valentine and all the people who have taken the time for this hearing today. These are tremendously important matters.

It's a real pleasure for me to be here this morning. I spend a great deal of my time talking to academic and citizen and consumer groups. There is a great deal of skepticism in the country today about the need for the kind of fiber future that we're talking about. There's a great deal of skepticism, a great deal of skepticism that says what we have today is good enough. It is a pleasure to be here this morning with people who share the same vision that we do—the vision of what the fiber future can bring to us.

Bell Atlantic is very interested in high-performance networks needed to provide the kind of services we've been talking about before, that we've been talking about this morning. We've built fiber optic networks to link commercial sites, colleges, universities, and public school systems in our region. We're already involved in three of the five test beds for the multi-gigabit communications network being built for the Corporation for National Research Initiatives as part of the National Research and Education Network planning. Within the Bell Atlantic region, these test beds include major research and commercial computing centers at Carnegie Mellon, Westinghouse, the University of Pennsylvania, Bell Communications Research, and Bell Labs.

I was very heartened this morning to hear the emphasis on the need to, wherever possible, turn to the resources of communications carriers like Bell Atlantic. I was very heartened to hear that emphasis today. Countries around the world are learning that the best way to manage a telecommunications system is not through a Government agency, but through private initiatives. From Australia to Argentina, countries are privatizing telephone companies, telephone networks that were once held in government hands, and they're doing that for a very simple reason: because private companies can do the job better. I guess that shouldn't be surprising. Private companies, because they want to put all the traffic on the same public network, can achieve tremendous efficiencies, efficiencies that aren't available when you try to isolate one kind of traffic to one kind of system and another kind of traffic to another kind of system.

The involvement of carriers like Bell Atlantic I think is important for several other reasons as well. Dr. Bromley talked about the need for interconnection. As the NREN—as this important national network is being built, carriers like Bell Atlantic are building our own modern intelligent networks. We're building them across our region, and it is critically important—critically important—that our intelligent network be able to talk to the gigabit network, to the very high-speed sophisticated network that we're talking about today. We need to be involved in the planning process for this modern network in order to ensure that that happens.

In the post-divestiture era, we have been through a number of situations where new technology has been introduced into the country in islands. There's an island of new technology here that can't talk to a different island at some distance. We cannot have that kind of development in this country. The reason that people like Bell Atlantic are so willing to be involved in this effort and so vigorously support this effort is that we want our networks, our intelligent networks, to be able to talk to this NREN network as well.

Mr. Chairman, one of the questions that was asked was— in the letter that was sent out to all of us—was what are the impediments? What are the regulatory or other kind of impediments that get in the way of getting this job done? I want to emphasize at the outset, Mr. Chairman, that whatever impediments there are, Bell Atlantic and companies like us are committed to doing our part. We will do everything we can. As I've indicated to you a few minutes ago, we are already heavily involved in this effort, and we want to be involved in this effort, but there continue to be significant impediments.

My testimony lists a number of those. Senator Gore this morning talked about the cable/telco cross ownership restrictions and the way that those interfere with the incentives to develop intelligent new networks. I would be remiss if I didn't mention the provisions of the Modification of Final Judgment, the degree that broke up the Bell system.

Let me just give you one example. We've heard several references this morning about the additional technological development that needs to be done in order to make modern networks a reality, and yet the decree prohibits the telephone companies, the Bell Companies, and also Bellcore, the research outfit that the seven regional companies own, from doing design and development work for new telecommunications equipment. Over half the telecommunications intelligence in this country is prohibited from having a good idea about how to develop this new telecommunications equipment. Now, I submit to you that is not the most efficient way to build the future. We have to think with all our brain, not just half of it.

You know, sometimes I think that telecommunications policy in this country is akin to something of a bad joke. We keep asking ourselves, "How many lawyers is it going to take to take this country into the information age?," and the answer to that question is, "I don't know, but a few more couldn't help." We have got to get to a situation where the people who are deciding what the networks of the future are are the technologists and the customers, like Dr. Ricart on my left, who really know what they need and know what the technology can develop. This shouldn't be hamstrung by regulatory restraints.

I don't want to close on a negative note, though. These are exciting times. The future is very bright. The possibility of the services that can be delivered over these networks are truly mindboggling. Bell Atlantic is very pleased to be a part of it. Thank you, Mr. Chairman.

[The prepared statement of Mr. Young follows:]

HIGH-PERFORMANCE COMPUTING ACT

OF 1991

H.R. 656

TESTIMONY OF JAMES R. YOUNG

VICE PRESIDENT, REGULATORY AND INDUSTRY RELATIONS

BELL ATLANTIC

BEFORE THE

SUBCOMMITTEES ON SCIENCE, AND TECHNOLOGY AND COMPETITIVENESS

OF THE HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

WASHINGTON, D.C.

MARCH 7, 1991

Good Afternoon. My name is Jim Young, and I am Bell Atlantic's Vice President for Regulatory and Industry Relations. I appreciate the opportunity to appear here today to discuss the "High-Performance Computing Act of 1991," and I would like to thank Chairman Boucher and Chairman Valentine for their interest in this matter. I would also like to congratulate your committees for having recognized the contributions that the nation's common carriers can make in building the National Research and Education Network.

Bell Atlantic is very interested in high-performance networks and computing. We have built fiber optic networks to link commercial sites, colleges, universities, and public school systems in our region. We are committed to building an advanced, intelligent public switched network. Two years ago, we filed waivers before the court that administers the Modified Final Judgment — the decree that broke-up the Bell System — for permission to provide supercomputer and centralized data processing services.

In fact, Bell Atlantic is already involved in three of the five "testbeds" for the multi-gigabit communication networks being built for the Corporation for National Research Initiatives as part of the National Research and Education Network planning. Within the Bell Atlantic region, these testbeds include major research and commercial computing centers at Carnegie Mellon University, Westinghouse, the University of Pennsylvania, Bell Communications Research, and Bell Laboratories.

Advanced Networks Promote Economic Growth

Cost effective, high-speed networks are essential to our future national competitiveness. This legislation envisions that a broad array of governmental data would become more widely available through a national high-speed network. That would be a very positive result. Information such as census data, business trends, natural resources, weather and climate is of greatest value when it is widely available to a large number of businesses for day-to-day as well as strategic business applications. The National Research and Education Network and widespread deployment of broadband facilities will facilitate ubiquitous access to information.

Today, approximately three out of every four jobs are in service related industries — industries that are increasing reliant on communications to increase their efficiencies. Recent studies show that the finance and business services industries have increased their real spending on telecommunications by four times during a recent twenty year study period and that, as a percentage of output, they doubled their telecommunications spending. These figures speak to the value of telecommunications and the need to ensure a modern telecommunications infrastructure.

While we are debating the need for a high-speed network, our major trading partners — and world-wide competitors — are moving ahead with plans to deploy fiber optic based digital networks. Japan, not surprisingly, has committed to building a 10 gigabit network similar to the National Research and Education Network and has committed to placing fiber optic technology to all of its homes and businesses by the year 2015. It is vitally important, therefore, for this country to move ahead promptly with the building of the high-speed network called for in the legislation. Failure to do so will negatively impact productivity, employment, the delivery of educational and health services, and our overall quality of life.

Common Carrier Participation is Essential

The nation's common carriers — the local exchange carriers and the long distance companies which operate the public switched network — have tremendous telecommunications expertise. Using that knowledge can accelerate the deployment and increase the capabilities of the proposed network. This does not mean that the entire effort should be left in private hands, but it does mean that you should look to these companies whenever possible.

Countries around the world are recognizing that telecommunications systems are run more efficiently by private entities than by governmental boards. That is why country after country — from the U.K. to New Zealand to Argentina — are privatizing their telecommunications networks.

Relying on companies like Bell Atlantic is in the public interest because these companies have a powerful economic incentive to put as many users on their networks as possible. Networks become more valuable as more users are linked. Consequently, with more users and higher volumes, per-unit costs go down.

To promote the commercialization of the technologies being sponsored by this legislation, common carriers should be allowed to:

- provide the transmission facilities, addressing and signaling, administration and maintenance,
- provide the customer billing and collection functions,
- provide the appropriate protocol and speed conversions that may be necessary to support a broader user base, and
- provide transmission facilities for lower speed, "dial-up" access to the network.

Such an approach allows the common carriers to achieve economies by incorporating the high-speed data networks into other network facilities. The result will be an accelerated deployment of high-speed networks and the parallel development of the support systems necessary for the operation of these networks. This will ensure widespread availability of this national resource.

Understanding Network Requirements Promotes Development of Standards

Common carrier participation in the National Research and Education Network is imperative because we are building our own intelligent networks. Therefore, coordinated planning is required to ensure that our networks are able to easily communicate with the National Research and Education Network. Early involvement of the nation's common carriers encourages synergies available through joint planning activities. The research supporting the National Research and Education Network will define computing, database, and switching architectures as well as the protocols having the most promise for future switching architectures.

Current Barriers Inhibit Bell Company Participation

You have asked what might inhibit the commercialization of the technologies and systems supporting the National Research and Education Network. I should emphasize that Bell Atlantic wants to assist with this effort and will do its best within the limits of current restrictions. However, without distracting this panel from the issues before it, Bell Atlantic and the other Bell companies will not be able to participate fully in the process because of the restrictions imposed by the Modification of Final Judgment — the decree that broke up the Bell System. I noted earlier the waivers pending before the decree court; other waivers were required and granted for the Bell companies' participation in a similar project of national scope — FTS2000. Our interests in promoting the availability of information services and our ability to participate in the design and engineering of advanced networks are severely constrained by the AT&T consent decree — yet our common carrier networks serve eighty percent of America's businesses and citizens.

Mr. Chairman, a few specific examples of regulatory and legal barriers that inhibit our participation are as follows:

- The Bell companies are prohibited from manufacturing, a term the courts have interpreted to include many research and development activities. The net result is that the Bell Companies spend only 1.6% of their revenues on research and development when all U.S. industry spends 3.4% and other large telephone companies, NTT and France Telecom, respectively spend 4.1 and 3.7% of their revenues.
- The Bell companies are barred from providing either information services content or associated data processing; both are activities encouraged by this legislation. Without such restrictions, the Bell companies would be incented to provide these services themselves and not request public funding.
- The Bell companies are prohibited from providing "long distance" services. However, the effect has also been to prevent the economies available from the centralization of information gateways and to require local exchange carriers to duplicate facilities and resources. As a result, the deployment of advanced functions is delayed.
- All local telephone companies are prohibited from providing video programming services within their service areas — absent waiver from the FCC. The result is an unregulated monopoly for the cable TV companies, who therefore have little incentive to use common carrier facilities. This eliminates potential revenue opportunities for the local telephone companies that could justify the accelerated deployment of fiber optic technology and the benefits it can bring.
- All local telephone companies operate under depreciation policies that maintain low basic telephone rates. As an extreme example of the disparities in policies, one can compare the depreciation policies of the U.S. with Japan; in general, their lives for central office equipment and fiber optic technology are 1/3 ours. The implications of these policies on incentives for manufacturers and on the availability of services are clear.

Even without relief, we will do our best to make modern, high-speed networks a reality. Legislative and court relief, however, will make it easier, and the country will benefit.

This is an exciting time. Your committees have a vision of what is necessary for encouraging supercomputing and high-speed networks. Such networks will be powerful vehicles for making supercomputing services more widely available and for encouraging the development of the commercial high-speed networks envisioned by this legislation. With the help of the Congress, the telecommunications and computer industries in this country, and the local telephone companies, we can make that promise a reality.

Thank you.

Mr. BOUCHER. Thank you, Mr. Young.

Dr. Johnston, we'll be pleased to hear from you.

STATEMENT OF GEORGE L. JOHNSTON, RESEARCH SCIENTIST, PLASMA FUSION CENTER, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Dr. JOHNSTON. Thank you, Mr. Chairman.

I am pleased and honored to be asked to testify here today. I am a Research Scientist in the Plasma Fusion Center of the Massachusetts Institute of Technology.

About a year ago, I began to think about the use of computer conferencing systems for the teaching of elementary and secondary science and mathematics. To understand the computer conferencing system, think about a situation in which a group of individuals pass by a physical bulletin board from time to time, read posted messages, and respond to them by posting additional messages. I was aware that isolation is a very serious problem in education both internally and in relation to the outside world, including an isolation from the scientific and engineering communities. Computer conferencing would certainly be of assistance here.

Since that time, I have been working with Mr. David R. Hughes, a pioneer in on-line communications and education. With his assistance in establishing a makeshift network and obtaining students, I taught a high school course on Chaos last semester to 25 students in Colorado, Montana, and Wyoming. This semester I am teaching the course to 20 students in California and Wyoming. All communications take place over ordinary telephone lines using modems.

In the year that I have been involved in this activity, I have become aware of the existence of a rich and growing diversity of education and research communities that use computer and communications technologies in similar ways. Although there is probably no single term adequate to describe these communities, I will adopt the term "K-16 communities" to describe them.

I believe that the experience of the course is a very positive one for the students. What I see as the principal issue here, however, is not the effect of the course on the students. It is good, but it is not unique, and it is being replicated in several other areas of the country. Rather the sole major issue which I wish to raise in my testimony is whether the act in its present form is supportive of efforts to use networks to build bridges between scientists and engineers and pre-university science and mathematics education or whether it needs to be amended in order to support these goals effectively.

Access to the Internet by connection to the NSF-funded mid-level networks has improved significantly in the last two years. Two years ago, the lowest network connect cost was $7,500 a year. Now, in some areas, anyone with a personal computer and a modem can obtain connection on a dial-up basis for as little as $2 an hour.

Now, the recent availability of inexpensive access to the Internet is a profoundly important development for the K-16 communities. It appears that it is likely to continue unless one or both of two possible developments disrupt the ability of the mid-level networks to continue and expand these services. One of these is the rise of unforeseen economic pressures exerted by the rapid movement toward commercialization of the delivery of network services. The other is the absorption of a disproportionate part of the funds available for network development by the costs of gigabit technology, which, although presently unknown, are predicted to be extremely high.

The continued availability of inexpensive access to the Internet for the K-16 communities can be assured by relatively minor amendments to the act. I shall suggest three amendments to accomplish that goal. First, the act should mandate the introduction of a strong advocate of the K-16 communities into the planning process for NREN. I have found no evidence that anyone involved in planning for the NREN and its implications for the Internet has been given responsibility to advocate and promote the interests of the K-16 communities. To the contrary, the FCCSET and the FNC charged by the legislation with the responsibility of implementing NREN are composed primarily of representatives of the Federal high-performance computing community.

Second, the act should provide for continuing study and monitoring of the needs of the various stakeholders and user communities and should ensure that appropriate technical and economical trade-offs are being made. Third, the act should indicate the strong and effective intent of Congress that free competition of the marketplace and the drive toward bandwidth shall not endanger the ability of mid-level networks, commercial providers, or State agencies to offer inexpensive connections to the public in general and the K-16 communities in particular. This intent should be effectuated both by the designation of a regulatory agency, such as the FCC, to see that the playing field is level and stays level and by the designation of an organization to engage in continuing policy studies and make periodic reports of its findings and recommendations.

I would like to add one other statement which is not in my prepared testimony, and that is the following: that it must be noted that many of the supercomputer centers are currently involved in outreach programs to the K-12 or K-16 community, so I would like to emphasize that although I have stated that there seems to be a problem with the influence of K-12 interests or K-16 interests in decision making, that many of the supercomputer centers themselves recognize the importance of outreach to the K-16 communities and are doing something about it already. Thank you very much.

[The prepared statement of Dr. Johnston follows:]

Testimony before the
Subcommittees on Science, and Technology and Competitiveness,
House Committee on Science, Space, and Technology,
concerning the
High-Performance Computing Act of 1991 {H.R. 656}

George L. Johnston
Research Scientist
Plasma Fusion Center
Massachusetts Institute of Technology
March 7, 1991

Introduction

I am pleased and honored to be asked to testify before the Subcommittees on Science, and Technology and Competitiveness of the House Committee on Science, Space, and Technology concerning the High-Performance Computing Act of 1991 {H.R. 656}.

Background

I am a Research Scientist in the Plasma Fusion Center of the Massachusetts Institute of Technology. My professional specialty is theoretical plasma physics. Prior to coming to M.I.T., I was a professor of physics at Sonoma State University, where I taught a variety of physics and astronomy courses to both science and non-science students.

About a year ago, I began to think about the use of computer conferencing systems for the teaching of elementary and secondary science and mathematics. A computer conferencing system is software that enables a number of individuals at locations remote from one another to exchange information on topics of mutual interest by means of personal computers, modems and telephone lines, and, possibly, computer networks. A computer bulletin board system (BBS) is similar to a computer conferencing system, but is less sophisticated. The conferencing is *asynchronous*, that is, messages are posted and responded to, at times convenient to each user. It is as if a group of individuals passed by a physical bulletin board from time to time, read posted messages and responded to them by posting additional messages.

The idea of using conferencing systems for education occurred to me as I was observing a bulletin board on the internal Digital Equipment Corporation wide area network at the home of a neighbor who is an employee of DEC. My neighbor's personal computer was connected to the network by means of a modem and a telephone line. The subject of the bulletin board, one of many on the network, was the Macintosh personal computer. A large number of questions concerning operation of the Macintosh, uploaded to the bulletin board by network users, was displayed on the computer screen. Next to each question was the number of responses to the question which had been uploaded. The responses to a particular question could be viewed by entering a command to the computer.

I had used bulletin boards before, as well as other features of networked computers, such as electronic mail. But suddenly an idea struck me: Why shouldn't this powerful capability be available for elementary and secondary education and not just for employees of technically sophisticated businesses, universities, government agencies, and the military? Of all the segments of U.S. society, elementary and secondary education is arguably the most distressed and in need of magic bullets, or something approximating them. I was aware that isolation is a very serious problem in education, both internally and in relation to the outside world, including an isolation from the scientific and engineering communities. Computer conferencing could certainly be of assistance here.

Since that time I have attempted to realize this initial vision. I have been working in collaboration with Mr. David R. Hughes, a pioneer in on-line commmunication in general, and on-line education in particular. With his assistance in establishing a makeshift network and obtaining the students, I taught a high school course on Chaos last semester to twenty-five students in Colorado, Montana, and Wyoming. This semester I am teaching the course to twenty students in California and Wyoming.

The courses are communicated over a small independent network that Mr. Hughes has established. It consists of two computers with Unix and MS-DOS operating systems in Colorado Springs, Colorado, and Dillon, Montana, and several other computers with MS-DOS operating systems at various locations in California, Colorado, Montana, and Wyoming. All communication between my computer at M.I.T. and Colorado, and between Colorado and the other three states takes place over ordinary telephone lines using $600 high-speed modems whose cost has declined by a factor of five in the past four years.

In the year that I have been involved in this activity, I have become aware of the existence of a rich and growing diversity of education and research communities that use computer and communications technologies in similar ways. They include individuals and organizations in elementary and secondary education, public and private, organized and independent. They include individuals and organizations in junior colleges, technical schools, and four year colleges. They include independent students and researchers, as well as small groups of students and researchers who can be characterized only by their common interest. Although there is probably no single term adequate to describe these communities, I will adopt the term "K-16 communities" to describe them.

Until recently, these communities have not had the degree of network access available to technically sophisticated businesses, universities, government agencies, and the military. Within the last few years, this situation has begun to change. My ability to become part of this change and to reach these students was due to a combination of two factors.

One was the foresight of U.S. West, the area's regional Bell operating company, in establishing Big Sky Telegraph. It is a statewide, grassroots educational microcomputer-based network in Montana, which is under the guidance of Mr. Hughes and its sysop (system operator), Prof. Frank Odasz of Western Montana College, the site of Big Sky Telegraph. The total expenditure for Big Sky Telegraph over a period of four years for equipment and staff salary has been less than $400,000.

The second factor was the visionary insight, enormous energy, and dedication of Mr. Hughes, a retired U.S. Army colonel, who over the past ten years has taught himself how to use computer and communications technologies for a large number of objectives, including the creation of such a low-cost network.

I believe that the experience of the course has been a very positive one for the students. It falls far short of realizing the full potential of the technology and methodology. It was developed on short notice with relatively meager resources. Nevertheless, a statement last semester by one of the teachers, Mr. David Sawtelle, describing an experience of his two students, suggests that our approach to the teaching of pre-university science and mathematics deserves further attention: "The investigation of those basins of attraction was one of the most valuable mathematical experiences that Matt and Seth could have had. They were truly 'doing' mathematics and tasted the excitement of research that I did not have until my senior year [in college]."

What I see as the principal issue here, however, is not the effect of the course on the students. It is good but it is not unique and it is being replicated (perhaps not as inexpensively) in several other areas of the country. Rather, the sole major issue which I wish to raise in my testimony is whether the Act, in its present form, is really supportive of these efforts to use networks to build bridges between scientists and engineers and pre-university science and mathematics education, or whether it needs to be amended in order to support these goals effectively.

Computer Networks for K-16 Communities

Access to the InterNet by connection to the NSF-funded mid-level networks has improved significantly in the last two years. Two years ago, the lowest network connect cost was $7,500 a year. Now the same kind of continuously open connect can be obtained for as little as $2,400 a year. Recently, many mid-level networks have begun to provide access to anyone willing to pay a small monthly fee. Anyone with a personal computer and a modem can obtain connection on a dial-up basis for as little as $2.00 an hour.

Two years ago the only hope of network connection for a high school was a corporate or NSF grant. Now any high school, technical school, or junior college with the requisite technical skill and a tiny budget can use the network. The problem of technical skill will be a formidable barrier to entry for most schools until training programs are implemented. Nevertheless, several dozen high schools and junior colleges have direct connections and many more have access by the hour. The door to affordable access has been opened by the NSF-funded mid-level networks as they seek to become commercially viable, self-sustaining, businesses. Also, state education agencies are in various stages of planning and implementing computer-communications networks for their schools and colleges, and plan to connect their state networks to the InterNet.

Threats to Continued Access for K-16 Communities

The recent availability of inexpensive access to the InterNet is a profoundly important development for the K-16 communities. It appears that it is likely to continue unless one, or both, of two possible developments disrupt the ability of the mid-level networks to continue and expand these services. One of these is the rise of unforeseen economic pressures exerted by the current rapid movement toward commercialization of the delivery of network services. The other is the absorption of a disproportionate part of the funds available for network development by the costs of gigabit technology, which although presently unknown, are predicted to be extremely high.

The occurrence of either, or both, of these developments would be a grievous setback for the goal of elementary and secondary school network use expressed by Congressman Brown and other members of the Committee and by the authors of *Grand Challenges: High Performance Computing and Communications*, published last month by Dr. Bromley's OSTP.

There is no indication at present that the provision of network services by commercial service providers such as Advanced Network & Services (ANS), Performance Systems International (PSI), and UUnet Technologies will result in disruptive competitive stresses on the mid-level networks. This commercial competition may have overwhelmingly beneficial effects. The provision of low cost network access by the mid-level networks occurred, however, without official sanction. Without an explicit mandate from Congress for the continuation of such open and inexpensive access, it could be lost if competitive pressures arise in the future.

The costs of gigabit technology, although at present uncertain, are predicted to be very high. The Federal Government will not have unlimited funds to connect every school in the U.S. to the InterNet within the next ten years. Likewise, it will not have unlimited funds to build multi-gigabit pipes to every university within the same period. Choices will have to be made. The Act addresses the development of gigabit prototypes. It does not address gigabit deployment in the post-1996 period. That will be extremely expensive. There is an economic tradeoff between the costs of deploying a multi-gigabit network for the computational scientific elite and the costs of connecting the K-16 communities to the network at much lower speeds. Until we have a much more accurate idea of the aggregate costs of these network connections, we will have no means of studying the tradeoff. The Congress should see that someone investigates these issues and reports back on the options.

Ensuring Continued Access for K-16 Communities

The continued availability of inexpensive access to the InterNet for the K-16 communities can be ensured by relatively minor amendments to the Act. I shall suggest three amendments which should provide protection against the two possible developments mentioned above which could disrupt the ability of the mid-level networks to continue and expand access for the K-16 communities.

First, the Act should mandate the introduction of a strong advocate of the K-16 communities into the planning process for NREN. I have found no evidence that anyone involved in planning for the NREN and its implications for the InterNet has been given responsibility to advocate and promote the interests of the K-16 communities. To the contrary, the FCCSET and the FNC charged by the legislation with the responsibility of implementing NREN are composed primarily of representatives of the Federal high performance computing community.

Second, the Act should provide for continuing study and monitoring of the needs of the various stakeholders and user communities, and should ensure that appropriate technical and economic trade-offs are being made. The Act presently contains no statements about estimated costs or conditions of construction of NREN.

Third, the Act should indicate the strong and effective intent of Congress that free competition of the marketplace and the drive toward bandwidth shall not endanger the ability of mid-level networks or commercial providers or state agencies to offer inexpensive connections to the public in general and the K-16 communities in particular. This intent should be effectuated both by the designation of a regulatory agency, such as the FCC, to see that the playing field is level and stays level so that there are no inhibiting factors on the ability of mid-level networks or commercial providers to offer low cost network connectivity, and by the designation of an organization to engage in continuing policy studies and make periodic reports of its findings and recommendations.

Conclusions

The InterNet is a network of networks. The development of multi-gigabit capability in an environment of commercialization and privatization, on the one hand, and of limited resources, on the other, makes it imperative that the merits of the entire spectrum of network users be balanced in the development of the NREN and its relation to the rest of the InterNet. The findings of the Act include the following statement:

> The United States currently leads the world in the development and use of high-performance computing for national security, industrial productivity, and science and engineering, but that lead is being challenged by foreign competitors.

It is widely believed that the United States trails its major industrial competitors in pre-university education, an area which is not unimportant for "national security, industrial productivity, and science and engineering." The use of computer and communications technologies offers a significant opportunity to achieve major improvements in pre-university education and benefits for the K-16 communities as a whole. Accordingly, the continued availability of inexpensive access to the InterNet for pre-university education, and for the K-16 communities as a whole, should be seen as a goal whose priority must be placed in perspective with that of other related goals, including the connection of supercomputers by multi-gigabit network technology.

Mr. BOUCHER. Thank you, Dr. Johnston.

Dr. Personick, we'll be happy to hear from you.

STATEMENT OF STEWART D. PERSONICK, ASSISTANT VICE PRESIDENT, INFORMATION NETWORKING RESEARCH, BELL COMMUNICATIONS RESEARCH, INC., MORRISTOWN, NEW JERSEY

Dr. PERSONICK. Thank you, Mr. Chairman.

My name is Stewart Personick. I am Assistant Vice President for Information Networking Research at Bell Communications Research. I am responsible for research in the areas of science and engineering that underlie new applications of communication to allow individuals and groups to interact across geographical barriers.

Bellcore is a telecommunications research and technology consortium owned by the seven regional companies, including Bell Atlantic, formed in 1984 upon the divestiture of the former Bell System. I'm happy to respond to the questions in the letter sent to me by Mr. Boucher and Mr. Valentine.

One, Technological barriers: In my own research laboratory, we are preparing experimental research equipment that can be used in conjunction with commercially available fiber optic transmission equipment to support communication and computor networking capabilities that are 100 to 1,000 times greater than what is currently available to researchers in the United States for performing computationally intensive tasks. This is consistent, of course, with the prior statements of Dr. Bromley.

Although there are many important open research questions that need to be resolved with respect to the most effective ways to implement these high-speed switched networks, and although widespread public deployment of gigabit networking in the United States awaits the resolution of these open questions, I believe that there are enough good ideas being proposed and enough promising alternative paths forward that the networking goals of H.R. 656 will be achieved, with the size and scope of the NREN dependent upon the level of funding.

Management options and strategies, transition of the NREN to commercial networking services, and the role of emerging commercial communication standards: I would like to suggest that all of the stakeholders, including the end users, the communications carriers, the communications equipment providers, Government and the regulatory community, all of the stakeholders should have the opportunity to participate in the management of the NREN in order to promote its maximum usefulness and to maximize the rate at which its benefits are made widely available to society. This is consistent with the statements that have come before. By involving all stakeholders, even if their current role is one of observation and learning, the transition of the NREN through its future phases will be greatly facilitated. However, along with the need to involve all stakeholders is also the need to avoid an unnecessarily cumbersome management structure.

With respect to the transition of the NREN to commercial networking services, I believe that this should be an ongoing objective, with the most leading edge needs provided by special configurations and with other needs supported by commercial offerings where economies of scale and scope and the reliability in features of these commercial offerings can be made available to end users. The NREN should make maximum use of emerging standards. By using available standards NREN customers will achieve the benefits of the economy of scale, ease of interworking and reconfiguration of resources, and the ease of use that comes with standards. Only applications at the edge of the technology forefront that cannot be effectively supported by existing standards should use other approaches. Those edge-of-the-art applications will lead to the next generation of standards if they become widely used by end users.

Three, potential barriers. I believe, as stated above, that the transition of the NREN to commercial network services should be an ongoing process with only the edge-of-the-art user applications supported by special networking configurations. At issue is the degree of economy of scale and scope that will be achieved by the use of commercial networking. This will depend on how much synergy there is between the networking needs of the NREN user community and the networking needs of the larger society, and this will also depend upon how rapidly a broadband infrastructure to meet the needs of society is deployed.

I do not believe that technology is the pacing item here. Although continued research and substantial development is needed to support the efficient widespread deployment of broadband networks, I believe that there are enough ideas and paths forward to meet the challenges ahead from a technology perspective.

The issues of finance, markets, and policy are intertwined in the highly bottom-line, next-quarter's-profit orientation of our society. Although this orientation leads to great efficiencies and can even spur innovation in some fields, it discourages long term, high risk investments. Many people are confident that broadband applications of great value to society are coming. However, the risks regarding exactly when they will come, how they will be provided, who will be allowed to provide them, and under what constraints prevent even the largest commercial enterprises from moving forward at a pace that will keep the United States competitive with Europe and Japan.

It is my view, therefore, that this is an opportunity for Government to invest in the future of the United States by acting as a facilitator of the long term evolution of the U.S. telecommunications infrastructure. The coordinating and seeding role of NREN is an important step in this direction.

Potential barriers and long lead time for the adoption of protocols and telecommunications standards: I have seen R&D programs that move slowly, and I have seen R&D programs that move very rapidly; for example, the emergence of fiber optics and progress in the power of computing systems. I have seen standards that move at a snail's pace, if at all, and I have seen standards that move at a rapid pace; for example, the recent emergence of synchronous optical network standards, otherwise known as SONET. I believe that the key to the rapid movement of R&D and the rapid movement of standards is teaming; teaming between those who will ultimately use the technology, including those who will create the technology and those who will make the investments to pay for the technology and its use.

When the needs of the application are clear and the urgency is a factor in the deliberations, standards move forward quickly. The discipline of involving users in testing out standards and in prototyping and test bed applications is essential to the rapid emergence of useful and usable standards.

Thank you, and I will be happy to answer any questions.

[The prepared statement of Dr. Personick follows:]

TESTIMONY

OF

STEWART D. PERSONICK

ASSISTANT VICE-PRESIDENT, INFORMATION NETWORKING RESEARCH

BELLCORE

ON THE

HIGH PERFORMANCE COMPUTING ACT of 1991

(H.R. 656)

BEFORE THE SUBCOMMITTEES ON

SCIENCE, and TECHNOLOGY and COMPETITIVENESS

U.S. HOUSE OF REPRESENTATIVES

MARCH 7, 1991

TESTIMONY
OF
STEWART D. PERSONICK
ASSISTANT VICE-PRESIDENT, INFORMATION NETWORKING RESEARCH
BELLCORE

ON THE
HIGH PERFORMANCE COMPUTING ACT of 1991
(H.R. 656)

BEFORE THE SUBCOMMITTEES ON
SCIENCE, and TECHNOLOGY and COMPETITIVENESS
U.S. HOUSE OF REPRESENTATIVES

MARCH 7, 1991

My name is Stewart Personick, Assistant Vice-President, Information Networking Research at Bell Communications Research, Inc. ("Bellcore"). In this position, I am responsible for research in the areas of science and engineering that underlie new applications of communication to allow individuals and groups to interact across geographical barriers, to allow individuals and groups to access stored information, and to allow computing resources to work cooperatively across a network in a distributed fashion.

These applications will allow individuals to communicate in multiple media: voice, full motion video, exchange of graphical materials, exchange of data, and will allow individuals to access information for educational, medical, business, and leisure activities in an efficient manner available to all members of society.

These applications will allow valuable computing and information storage systems to be shared efficiently, and to be brought to bear collectively where their combined capabilities are needed.

I am also responsible for the identification of the scientific and engineering barriers that might stand in the way of the realization of these information networking capabilities, for research directed toward the removal of those barriers through invention, and for the demonstration of research experimental prototypes of information networks and applications that demonstrate the technical feasibility, usefulness, and usability of the applications.

I have done research in telecommunications technologies and applications since 1967 at Bell Telephone Laboratories (1967- 1978), TRW Inc. (1978-1983), and at Bellcore (1983-present). I have served on several U.S. Government Panels and Committees-most recently the National Research Council Photonics Science and Technology Assessment Panel (1988).

Bellcore is a telecommunications research and technology consortium owned by the seven Regional Companies formed in 1984 upon the divestiture of the former Bell System. Bellcore serves as a central point of contact for National Security and Emergency Preparedness for the telecommunications affiliates of the seven Regional Companies. In addition Bellcore conducts extensive research, systems engineering, and software systems development for its owner/clients.

I am happy to have the opportunity to respond to the questions in the letter sent to me on March 1, 1991 by Representatives Rick Boucher and Tim Valentine.

1. Potential Technological Barriers to Achieving a Gigabit National Research and Education Network (NREN)

To put my answer into a proper perspective, I would define a successful gigabit

National Research and Education Network as one that enables useful and usable end user applications, which benefit in a demonstrable way from a communications network that can support peak data rates of 1 gigabit per second or more, and/or which benefit from an aggregate backbone rate of 1 gigabit per second or more.

I believe that the technology necessary to support switched communications among a large number of locations with available peak data rates at or above 1 gigabit per second and aggregate backbone rates of several gigabits per second will be forthcoming in the research laboratory environment and in initial networking applications (available for use in the implementation of NREN) in the next several years. In my own research laboratory, we are preparing experimental research equipment that can be used in conjunction with commercially available fiber optic transmission equipment to support switched networking at aggregate rates of 2.5 gigabits per second, and peak individual user rates of 622 megabits per second. In conjunction with Bell Atlantic, NYNEX, MCI, IBM, MIT, and the University of Pennsylvania, we will demonstrate, using experimental research equipment, 2.5 gigabits per second aggregate rate networking in a testbed called Aurora which will be one of the testbeds under the umbrella of the Gigabit Networking program being supported in part by the Defense Advanced Projects Research Agency (DARPA) and the National Science Foundation (NSF) working in conjunction with the Corporation for National Research Initiatives (CNRI). Although there are many important open research questions that need to be resolved with respect to the most effective ways to implement switched networks at 1 gigabit per second and beyond, and although the wide spread deployment of gigabit networking capabilities in the

United States awaits the resolution of those open questions, I believe that there are enough good ideas being proposed, and enough promising alternative paths that can be pursued, that the networking goals of H.R.656 will be achieved; with the size and scope of the NREN dependent upon the level of funding.

There are two additional technical issues I would like to address. The first is how one interfaces computing systems (e.g., processors, storage devices, workstations) to the network to utilize the gigabit per second peak data rate capability. The second is the issue of demonstrating persuasive end-to-end applications which make good use of the gigabit per second peak data rate and/or the aggregate gigabit per second backbone capacity. Initial research results appear very promising in both of these important issue areas, and it is my belief that there will be rapid progress in identifying increasingly effective ways to interface computing systems to gigabit networks, and in identifying applications that demonstrate the power of gigabit per second networking in performing important tasks. To substantiate this, I point to the progress being made in research in what communications experts call "protocols" for making effective use of gigabit per second networking resources. Lower speed networks employ protocols (which are essentially procedures for preparing information for transport across a network and assuring that it has been delivered properly and safely) that are optimized for lower speed networks, and which in many cases were designed to accommodate the vagaries of transmission across microwave, satellite, and metallic cable (e.g., copper wires) physical media. Because of the speed-of-light delay associated with all networking, these protocols do not support efficient networking at gigabit per second speeds over long distances. However, we are seeing rapid progress in the research laboratories in the identification of candidate protocols that capitalize on the excellent transmission performance of modern fiber optic systems, which are properly tuned to the tradeoffs of high speed networking in general, and which show great promise of providing efficient interfacing between computing equipment and gigabit per second networks. Thus although many open questions remain, there are again many possible ideas being pursued in the research laboratories, and I believe the biggest issue will be in choosing the best among them for widespread use in standardized applications.

With respect to the end-to-end applications that will gainfully employ the gigabit per second networking capabilities, here too I see no insurmountable technological barriers. The tough research questions here are in quantifying the tradeoff between local computation and inter-computing resource communication in accomplishing complex and computationally intensive tasks. This is a classic tradeoff where leading edge end-to-end applications tend to require access to expensive and beneficially shared computing resources (accessed via networking capabilities), and more established, less demanding applications migrate toward local implementation. We have seen this trend in the migration of some task, from formerly being performed on large mainframes, to workstations. Only with further research and experimentation will these tradeoffs between local and distributed computing be tested and more thoroughly understood. However, that is in itself a part of the NREN objectives.

2. Management Options and Strategies for the NREN, Transition of the NREN to Commercial Networking Services, The Role That Emerging Commercial Communications Standards Should Play, E.G., Open System Interconnection

Protocols (OSI), Broadband Integrated Services Digital Network (ISDN), and Synchronous Optical Network.

I have recently been invited to participate in a number of forums where management of the NREN is being discussed. However, at this time I do not feel qualified to give a comprehensive answer to the question of how the NREN should be managed. I would like to suggest however, that participation by all of the stakeholders — including: the end users who have computationally intensive tasks to get done, the computer communication research community who must understand the end-users' needs and translate those into continual improvements in the NREN, the carriers who may initially provide transmission and switching functionality and who may later support the NREN applications as part of a more widely deployed commercial infrastructure, the equipment providers who manufacture telecommunications transmission and switching equipment, the government, and representatives of the regulatory community — should have the opportunity to participate in the management of the NREN in order to promote its maximum usefulness and to maximize the rate at which its benefits are made widely available to society as a whole. By involving all stakeholders, even if their current role is one of observation and learning, the transition of the NREN through its future phases will be greatly facilitated. However, consistent with the need to involve all stakeholders is the need to avoid an unnecessarily cumbersome management structure.

With respect to the transition of the NREN to commercial networking services, I believe that this should be an ongoing objective, with the most leading edge needs provided by special configurations, and other needs supported by commercial offerings where economies of scale and scope, and the reliability and features of the commercial networks can be available to the end users.

The NREN should make maximum use of emerging standards such as SONET, Broadband Integrated Services Digital Network (ISDN), and Open Systems Interconnection (or equivalent widely adopted standards). By using available standards, NREN customers will achieve the benefits of economy of scale, ease of interworking and reconfiguration of resources, and ease of use that comes with standards. Only applications at the edge of the technology forefront that cannot be effectively supported by existing standards should use other approaches. These edge-of-the-art applications, of course, lead to the next generation of standards if they become widely used by end users.

3. Potential Barriers (Technical, Financial, Markets, Political) with Respect to the Transition of the NREN to Commercial Network Services

I believe, as stated above, that the transition of the NREN to commercial network services should be an ongoing process, with only the edge-of-the-art end user applications supported by special networking configurations. At issue is the degree of economy of scale and scope that will be achieved by the use of commercial networking. This will depend upon how much synergy there is between the networking needs of the NREN user community and the networking needs of the larger society, and upon how rapidly a broadband infrastructure to meet the needs of society is deployed. I do not believe that technology is the pacing item here. Although continued research and substantial development is needed to support the efficient widespread deployment of broadband networks, I believe that there are enough ideas and paths forward to meet the challenges ahead from a technology perspective. The issues of finance, markets, and policy (a part of the political dimension) are intertwined in the highly bottom-line, next-quarter's-profit orientation of our society. Although this orientation leads to great efficiencies and even can spur innovation in some fields, it discourages long-term high-risk investments. Although many people are confident that broadband applications of great value to society (in education, medicine, business, and leisure activities) are coming, the risk regarding exactly when they will come, how they will be provided, who will be allowed to provide them, under what regulatory constraints, etc., prevent even the largest commercial enterprises from moving forward at a pace which will keep the United States competitive with Europe and Japan. In my view, this is an opportunity for government to invest in the future of the United States by acting as a facilitator of the long term evolution of the U.S. telecommunications infrastructure. The coordinating and seeding role of the NREN is an important step in this direction. NREN will facilitate the identification of the applications that can be of most value to end users in very high speed networking, and will also help to identify the most effective technologies for meeting those applications. Another dimension of this is to make sure that laws and policy in general evolve to remain consistent with the best interests of the society in the domain of telecommunications.

4. Potential Barriers Associated with the Nature of R&D and the Long Lead Time for the Adoption of Protocols and Telecommunications Standards

My experience over the last 24 years leads me to conclude that neither the nature of R&D nor any intrinsic nature of standards is a barrier to rapid progress in the realization of the NREN and its ongoing transition to the use of commercial networks.

I have seen R&D programs that move slowly, and I have seen R&D programs that move very rapidly (e.g., the emergence of fiber optics, progress in VLSI, progress in the power of computing systems). I have seen standards that move at a snail's pace (if at all), and I have seen standards move at a rapid pace (e.g., the Synchronous Optical Network, SONET standards). I believe that the key to the rapid movement of R&D and the rapid movement of standards is teaming between those who will ultimately use the technology, those who will create the technology, and those who must make the investments to pay for the deployment and use of the technology; as well as other stakeholders such as government. When the application is well understood, and the demand for a new enabling technology is clear, then progress occurs rapidly on all fronts. Basically, the controlling factor in progress in R&D and in standards is uncertainty: uncertainty in what is needed, and uncertainty as to when it is needed. Given uncertainty as to what is needed and when it is needed, one can engage in standards discussions of alterative approaches for all eternity. It is seldom the case that one approach under consideration in a standards body is unquestionably better than other approaches under consideration for all possible assumptions about what the application is. It is only when the needs of the application are clarified, and urgency becomes a factor in the deliberations, that standards move forward quickly. In addition, the discipline of involving users and testing out standards in prototyping and testbed applications is essential to the rapid emergence of useful and usable standards.

Therefore, I believe that the NREN will be an enabling factor in the rapid emergence of useful and usable standards, because it will clarify the needs of end users and it will provide a testing ground for alternative standards proposals. I anticipate that future commercial networking standards will not only emerge more quickly, but will be better standards (in terms of their applicability and their performance and cost effectiveness) because of the discipline that testing on the NREN will impose.

5. Comments on the Overall Scope and Focus of H.R. 656

I strongly support the objectives of H.R. 656 because I believe that it will be a catalyst in the emergence of the future broadband networking infrastructure of the United States, and because it will meet the urgent needs of the research community of the United States for a broadband research infrastructure.

Mr. BOUCHER. Thank you very much, Dr. Personick, and the Chair thanks all of our panelists this morning.

Let me start with just the very broad issue. It seems that everyone who has testified here today and as I hear statements from members of the two subcommittees, I think it's clear that there's a uniform view that there is a role for the Government in helping to jump-start this process.

Just to put that question directly to each of you, though, I would appreciate a comment from each of you about what you think would happen in terms of continued research on gigabit technology in the event that there was no Government role. Suppose we did not have this initiative. What would be the effect, and I suppose the extension of that question is why is the Government role so necessary?

Mr. Young, let's start with you.

Mr. YOUNG. Well, even without a Government role, of course, research on gigabit transmission is going forward, but I think what this program provides is an important sort of demand pull. We all know the technology is there and being developed for a modern fiber network. What we need are the uses of that network so that the revenues will be there so that we can go ahead and build it.

You know, I spoke about the forums that I go speak to from time to time about the future of the fiber network, and sometimes I am greeted with sort of a sarcastic reference to a baseball movie you may have seen a couple of years ago, "Field of Dreams." I'm accused of preaching the gospel that if we build it, they will come. To have some very concrete uses that are coming on board, I think this does a great deal to help stimulate the development of the technology.

Mr. BOUCHER. All right.

Dr. King?

Dr. KING. With Government's support—

Mr. BOUCHER. Could you turn your microphone on, please?

Dr. KING. With Government's support, the interim NREN, the NSFNET, has grown at a remarkable pace over the last three years. If this support were to disappear, I think the investment that's needed in higher education and in industry to continue to evolve the network would disappear. I think the Government role is critical but in partnership with all of the other constituencies. The investment that all of us are making, the non-Government elements of this partnership are making, is probably of the order of 10 times the investment that the Government is making. So a partnership is critical. We all need to invest, but the Government investment and support is critical.

Mr. BOUCHER. All right.

Dr. Ricart?

Dr. RICART. The best institutions in the country are already in some sense the elite and in some sense don't have the same kind of need to share that information and share their expertise with other schools and colleges that other schools and institutions do. If we don't have Government support for the NREN, we will not have the kind of leadership from the most prestigious research institutions in the United States that I think that you would otherwise see. It's sort of like two experts meeting in the hall. If one asks the other a question, the first has to give a very good answer to prove that he or she is an expert, and having a Government-sponsored NREN will promote that kind of interchange and the democratization of the kind of science and research that I spoke about in my testimony.

I think there's a third piece, and that is that you've heard a number of technological buzz words today—synchronous optical networks and multi-megabit digital service. We need to make some choices among these technologies, and by having a Government leadership role, especially from the funding agencies—the National Science Foundation, the Department of Energy, and others—we're going to get those appropriate selections out in the field so we don't have to argue about them, and I think that that role alone is something that the existing NSFNET has proven to be of great value.

Mr. **Boucher**. Dr. Johnston?

Dr. **Johnston**. Recently I saw a news item in a data communications networking magazine to the effect that Levi Strauss and Company, the makers of Levis and other clothing, was going to change its network affiliation and was going to go to a private network which would be a very sophisticated private network. As I recall, it included video, voice, and data.

Now, it seems to me that if there is not Government funding forthcoming for the NREN and for related activities that Levis will be designed and marketed with the help of this very sophisticated network, but people who are trying to do something about the K-16 communities and the education will be left behind where they are now.

I think I can illustrate where they are now. I didn't mention this in my presentation, but in teaching the Chaos course, I have been using ASCII text because that is the only interoperable system of communication that's available to me now. In other words, the only kind of graphics that is available to do what I want to do is the old character graphics, which one may remember from 20 years ago the pictures of Snoopy on the door of the computer center, all drawn with asterisks and periods and exclamation points and so on, and similarly, as far as equations are concerned, we just had to make that up and wing it pretty well. So it seems to me that for a variety of matters that are a public concern as opposed to private concern, one really has to have some sort of Government investment. Thank you.

Mr. **Boucher**. Thank you.

Dr. Personick?

Dr. **Personick**. I believe, as was mentioned by Dr. Bromley, that information will be the—and Senator Gore— that information will be the strategic advantage of the future, and I believe that the free enterprise system of this country, as well as our technology base, has prepared us well to maintain our leadership role. But every system has its limitations, and our system needs a little bit of a kick start. The extreme near-term, bottom-line, next-quarter's-profit orientation of our society prevents us as a community of enterprises from taking advantage of our accumulated technology, and that is the role that I think this plays.

Mr. **Boucher**. Thank you for those comments. I noted and want to say that we very much appreciate the recommendations that many of you have made with regard to ways that we can improve the statute. We'll certainly try to take those concerns into account.

One item that you did not mention and I'd like to focus your attention toward this is the possible need, as designated in the statute, for a lead agency among the various agencies participating in this effort that would manage the day-to-day operation of the network. Under the current arrangement, the Office of Science and Technology Policy is coordinating the planning function for the research, but do we need, in your opinion, a lead agency that would have day-to-day management responsibility and ultimately could plan such functions as access to the network and billing for that access, the establishment of charges for appropriate levels of service, and the like? Any comments that you have concerning that, and if you believe that a lead agency is necessary, any particular candidate that you might have for that function would be helpful as well.

Dr. Ricart, I see you smiling. Are you prepared to answer that?

Dr. RICART. I think in fact there is a need for a lead agency, and I believe that the National Science Foundation, because of the breadth of research that it covers and because of its great degree of input from the research and education community which I emphasized earlier in my testimony, would be the agency that would be best able to provide an education and research network that serves research and education.

Mr. BOUCHER. Thank you.

Dr. King?

Dr. KING. Over the last three years, the National Science Foundation has in fact been acting as the lead agency in developing the interim NREN, or the NSFNET, and I think that's worked, and the working relationships between higher education, industry, and Federal agencies—in particular, the National Science Foundation—has been very good. All of the agencies, however, have a role, and it is critical that they cooperate.

Mr. BOUCHER. Thank you.

That's two votes for the National Science Foundation.

[Laughter.]

Mr. BOUCHER. Mr. Young?

Mr. YOUNG. Well, Mr. Chairman, I hope it doesn't sound too cynical, but I'd like to put in a vote for Bell Atlantic.

[Laughter.]

Mr. YOUNG. In all seriousness, I think the management function that you're talking about maybe breaks down into a couple of parts. There's sort of an overall policy management, and it just seems to me as a matter of good management, having a lead agency makes a good deal of sense. But consistent with my remarks before about commercialization and privatization, I think that sort of the technical and billing management of a system is something that you ought to think very seriously about putting out an RFP for and getting bids from carriers to do because that's the kind of thing we do best.

Mr. BOUCHER. I think, if I might respond, that ultimately that would happen, but some agency needs to have the overall responsibility for governing that process, and I think what we're talking about here is a lead agency that would put out the RFP to the private sector.

Mr. Young. And I would have no quarrel with that.

Mr. Boucher. Can we count it three votes, then, for the NSF? [Laughter.]

Mr. Boucher. Dr. Johnston?

Dr. Johnston. I would like to add a conditional vote for NSF. The condition that I would like to state is that the legislation would clearly state the intent of Congress that the interests of all the stakeholders and user communities be considered by the agency that's managing the net. Thank you.

Mr. Boucher. Thank you, sir. That point was, I think, very clearly made earlier by Dr. Ricart that we need to have some clear direction in the legislation that the user community be consulted as the plans advance for this research effort, and that point is duly noted.

Dr. Personick?

Dr. Personick. Yes, I would like to say that I'd like to separate leadership and management, and I would greatly support the NSF in the leadership role; and as far as the management's concerned, I think that it might be appropriate to consider the comments of Mr. Young.

Mr. Boucher. Thank you very much, gentlemen. That concludes the Chair's questions, and I would recognize now the ranking minority member, the gentleman from California, Mr. Packard.

Mr. Packard. Thank you, Mr. Chairman.

For the six years I've sat on this committee, each time we hold a hearing of this nature I feel like I've been in a post-graduate course or had a crash course on some very interesting and intricate part of science. It's been a very interesting experience for me this morning.

I'll be brief in my questions and perhaps also request a brief answer. In these proposals, NREN is to become a workable system by the year 1996. Can it be done? And let me direct it to two phases of the witnesses—one to the educational phase and one to the private sector—Dr. King and Dr. Personick.

Dr. King. Yes, it can be done. The original plan proposed by the Office of Science and Technology Policy, which, I think, was published in 1987 and revised in 1989, has a set of milestones for upgrading the capacity of the network, and those milestones are on schedule. The current interim NREN will have an operational 45-million-bit-per-second backbone sometime in the next few months, and the test beds are testing the technology that will move us to the gigabit level. So the people in the laboratory are confident that this goal can be reached, and I'm confident it can be reached.

Mr. Packard. Dr. Personick?

Dr. Personick. Yes, for the sake of brevity, I'll simply say that I'm confident that all the goals in H.R. 656 are achievable with the technology base that we have, from a technology point of view.

Mr. Packard. Dr. Ricart and Dr. Young, do we have the capacity or the ability rather—if we do develop the system by the scheduled time, then do we have the ability to use the capacity effectively? Let's go again to the educational side and then to the private sector side.

Dr. **Ricart**. I think it will take the cooperation of Government, research, and industry in order to bring about the kind of system that will in fact be used heavily by these groups. There are a number of applications on the horizon right now, some of which we have demonstrated on a prototype basis, that would easily require all of this bandwidth and perhaps even request additional bandwidth beyond what the legislation provides. I don't think that we're looking at a closed-ended 1996 gigabit, that's-it-everyone-can-go-home system. I think that's the plateau at which we can next look.

Mr. **Packard**. Thank you.

Mr. Young?

Mr. **Young**. Yes, sir. I am confident that there are enough innovative services out there to make use of this network. We focused on a lot of the academic applications this morning. The backbone fiber network and the other networks that it would spawn, interconnect with, and work with could provide a host of other services. We've talked about distance learning today, the ability of somebody standing in a classroom to interact with students hundreds of miles away just as easily as we're interacting now, with the same animation, with the same liveliness, with the same immediacy.

Health care applications are substantial. Imagine what it would be for someone in their home to be examined by an expert physician who is in his office or her office. The patient never has to leave the home to do that, and the doctor in turn can, in aid of that examination, do immediate research based on the symptoms to prescribe something for the patient. Think about long term health care for the Nation. The possibility that nurses, for example, could monitor patients in their home giving them the kind of care that they might have today in a nursing home but at a fraction of the cost, allowing those people to stay in their homes, stay in their communities, stay with their families, improving their quality of life.

The kind of uses that this kind of network could bring to the public are immense. Twenty years ago or 30 years ago or 25 years ago, when touch-tone calling was implemented, I don't think anybody had any notion of the many uses that that little pad could have, yet they've developed. The same will happen with this kind of network.

Mr. **Packard**. That's very interesting. Thank you.

In Dr. Bromley's testimony, he expressed concern and questions related to it as to whether these proposals had the flexibility in the rapid advancement of computer technology and the changes that will take place during this five-year planning process and implementation and development process. I'd be interested in your observations as to whether it is— how essential it is and how it could best be done to bring about that kind of flexibility that would allow upgrading and updating.

Any comments? And I don't need to hear from everyone, just those that would like to respond.

Dr. **King**. I would comment that if a mechanism is provided for the users of the network and the participants from industry and higher education and Government to have a joint role in determining how the network evolves, and if the bill, as it does, provides for some mid-course correction points, then I think that there's no problem with respect to flexibility.

Mr. **Packard**. Thank you.

Dr. **Ricart**. The bill is not very specific in terms of the technology. It is specific in terms of a process. I think that the process that calls for revision of the plan provides all the flexibility that's needed, and I'm not sure that we would want the flexibility to be, for example, changing lead agencies every two years.

Mr. **Packard**. Good point.

Mr. **Young**. I tend to agree with Dr. Ricart. I think there is a great deal of flexibility in the legislation. Certainly, it would be counterproductive for any oversight group to try to dictate the technology or dictate the technological evolution. That will take care of itself, I think.

Mr. **Packard**. It was noted that—at least I noted— that two out of the five of your testimonies specifically mentioned libraries as being left out of the plan. Are there other agencies or other opportunities that may be considered besides libraries? And I think that we ought to certainly note that, that there could be another input from libraries, the national library system.

Yes, sir, Dr. Johnston?

Dr. **Johnston**. I think that if you compare the language of last year's Senate bill with the language of this year's bill, which is very similar to the bill being considered here, there is a change which seems to eliminate libraries and education. Unfortunately, I don't have those texts with me now, but I know a lot of people here know the compression I'm referring to, and I think there is a widespread concern that in this bill that somehow libraries and education have been— that their objectives, their goals have been deemphasized or left out.

Mr. **Packard**. Thank you.

I think I'll close at that, Mr. Chairman. Thank you very much.

Mr. **Boucher**. The Chair thanks the gentleman and also extends its thanks to this panel of witnesses. We particularly appreciate the recommendations that you've made for improvements that we should consider for this legislation. We will take those comments into account as we move this process forward. Again, the Chair extends its thanks to this panel of witnesses.

Mr. **Boucher**. We will now welcome our fourth panel of witnesses, and each of these gentleman are invited forward: Dr. Paul Young, Professor of Computer Science, University of Washington, and Chairman of the Board of Computing Research Association; Dr. Greg McRae, Professor of Chemical Engineering and Professor of Engineering and Public Policy, Carnegie Mellon University; Mr. James E. Rottsolk, the President and Chief Executive Officer, Tera Computer Company; and Dr. Larry Lee, Executive Director, North Carolina Supercomputer Center, Research Triangle Park.

Gentlemen, we welcome each of you here this morning. Without objection, your prepared statements will be made a part of the record. The Chair would remind the witnesses of the five-minute rule for providing oral statements, and we would be happy to receive those beginning with Dr. Young.

STATEMENT OF PAUL YOUNG, PROFESSOR OF COMPUTER SCIENCE, UNIVERSITY OF WASHINGTON; CHAIRMAN OF THE BOARD, COMPUTING RESEARCH ASSOCIATION, WASHINGTON, D.C.

Dr. YOUNG. Mr. Chairman, it's a pleasure to be asked to testify at this joint hearing on H.R. 656, the High-Performance Computing Act of 1991. While I'm Professor of Computer Science and Engineering at the University of Washington, I speak here as Chair of the Board of Directors of the Computing Research Association. I would like to thank this committee, as well as Senator Gore, for the strong interest and support you have demonstrated over the years for both computing research and also research computing.

We stand today at a turning point in the history of computing. Because we are rapidly approaching fundamental physical limitations on the speed of single-processor computers, the day of rapid advances in the design and technology of single-processor computers and supercomputers is coming to an end. Nevertheless, the computing research community is convinced that we have only begun to realize the benefits of high-performance computing.

Today's most powerful machines are able to perform over a billion fundamental arithmetic operations per second. While this sounds a lot, it is not enough to solve some of the most important problems of science and engineering. To achieve the 1,000-fold increase in performance mentioned by Dr. Bromley, it will be necessary for future machines to use thousands of processors operating in parallel and interactively to execute a trillion arithmetic operations per second. When fully realized, such machines and their attendant software will enable us to solve a dramatic number of the grand challenges of science and engineering.

For example, it will be possible to build large and realistic climate models which will help make long range weather predictions and which will help predict and understand global climate changes. It will be possible to model the human genome. Furthermore, it will be possible to accurately and precisely simulate directly from basic theoretical principles, with no simplifying assumptions, turbulence around an aircraft, combustion in rocket engines, and the dynamics of matter in distant galaxies.

The ability to make such large calculations from basic scientific principles is already changing our understanding of the scientific method, and this process will accelerate as we understand, build, and learn to use large, massively parallel machines. This process is so fundamental and revolutionary that computation is now joining physical experimentation and mathematical analysis as one of the key basic paradigms for how science gets done. But at the same time, we do not yet know the correct computer architectures, algorithms, and software to fully realize the benefits of this coming revolution in massively parallel computation.

As Ken Kennedy, who is also on our Board, testified last year, "Converting to the massively parallel machines of the sort that will dominate the next generation of supercomputers will require an enormous retooling effort. We will need to replace 30 years of problem solving methods for conventional computers with new methods that can take advantage of high degrees of parallelism to solve problems more rapidly." To respond to this challenge, this country needs a coherent plan for supporting the necessary basic research on appropriate algorithms, data structures, software, and hardware to achieve the benefits promised by massively parallel machines.

Development of human resources will also be critical if we are to fully realize the benefits of high-performance computing. Professor John Rice, a computer scientist from Purdue University and a member of our Board, discussed computational science education in the January issue of Computing Research News. He described the problem as follows: "Too often the computing knowledge of highly trained engineers and scientists working on computational science and engineering projects is at the college sophomore level or lower. Too often we have highly trained computer scientists whose knowledge about engineering and science is at the sophomore level or lower." We will need to increase the number and level both of scientists and engineers trained in computer science and engineering and of computer scientists and engineers trained to explore the deep research questions raised by "grand challenge" scientific and engineering problems.

As I wrote these notes for my Congressional testimony, I used windowing software packages which were distributed, refined, rewritten, and popularized by researchers who used the network as a giant laboratory both to develop and distribute the system. The night the Berlin wall came down, I was busy using an international network to work with a young graduate student in West Berlin, developing algorithms and working through the final difficult stages of a paper we were jointly writing.

At the other extreme, I recall my conversations in the early summer of 1989 with two Soviet scientists from the Russian science city of Novosibirsk. I was discussing with them our country's networks and our capacity for rapid, indeed instantaneous exchange of information and data. One of the Soviet scientists said, "Ah, but we, too, have electronic data transfer. When we want to transfer data from Novosibirsk to Moscow, we hold our regular computations, print out the data on a tape, get permission of our director to send the data to Moscow, and send the tape via an airplane where it is easily read back into a computer. The whole process rarely takes more than several days." To which his colleague added, "Yes, in theory this is the way it works, but unfortunately, in the Soviet Union, transfers seem to work only when they go from Moscow to Novosibirsk."

Current networks developed by NSF and DOD have already had an enormous impact on how computer science and engineering and science and engineering in general gets done in this country, but as the coming generation of high-performance computing systems are realized, we will need new networks supporting massive and instantaneous data movement and management. Basic research in computer graphics, visualization, human interfaces, network protocols, software systems, and data base management will result in a new form of massive collaboration enabling such networks to unite the Nation's computing technology and research, forming a giant co-laboratory for computing research and development.

I believe that H.R. 656 forms the basis for a well balanced program which, if fully implemented as part of a five-year program of increased support for high-performance computing, will go far to assure this country's continued lead in computer science and engineering.

Reiterating, the Computing Research Association supports a balanced multi-agency program with support for all of the critical elements needed to assure this country's lead in high-performance computing. We believe that H.R. 656 should explicitly authorize funding for basic research and the development of human resources and computer science and engineering. These are essential if the other components of the program are to be fully realized.

I believe that a high-performance computing program authorizing requisite basic research and development of human resources is essential if the United States is to maintain its leadership in high-performance computing into the next century. Our country can afford no less. Thank you.

[The prepared statement of Dr. Young follows:]

TESTIMONY

by

DR. PAUL YOUNG

PROFESSOR OF COMPUTER SCIENCE, UNIVERSITY OF WASHINGTON
CHAIR, BOARD OF DIRECTORS, COMPUTING RESEARCH ASSOCIATION

delivered at a Hearing of

THE HOUSE SUBCOMMITTEE ON SCIENCE
AND THE HOUSE SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS

MARCH 7, 1991

Mr. Chairman, it is a pleasure to be asked to testify to this joint hearing on H.R. 656, The *High Performance Computing Act of 1991*.

I am Paul Young, Professor of Computer Science and Engineering at the University of Washington and Chair of the Board of Directors of the Computing Research Association. The membership of the Computing Research Association is composed of PhD–granting academic departments, as well as industrial laboratories, that engage in basic and applied research in computer science, computer engineering, and computational science. Most major research Departments in the U.S. and Canada are members.

I would like to thank this Committee, as well as Senator Gore, for the strong interest and support you have demonstrated over the years for both computing research and research computing. Through authorizations, particularly to NSF, and through a series of bills of which H.R. 656 is the latest, you have continued to focus attention on what we consider to be a critical "enabling technology." CRA strongly supports this bill, particularly its recognition that basic research and human resource development must accompany the more focused technology and infrastructure development.

The Critical Importance of High Performance Computing

Our support for this legislation and related initiatives is predicated on a set of observations which we believe to be widely shared within the research community, government and industry.

1. Advanced computing and communications technologies are no longer just interesting new tools for some limited class of users, but are converging together to form a necessary digital information infrastructure that will be basic to our society—throughout areas such as science and engineering, manufacturing and commerce, government, and education.

High performance computer systems underpin much of science and engineering: from medical imaging, to aerospace design, to the development of less environmentally toxic chemicals and industrial processes. High performance computer systems lie at the heart of large research instruments such as accelerators and telescopes, controlling their operation, analyzing their performance, and directing the flow of experimental data that the instruments produce. Large-scale data base technology is needed to store and organize the massive amounts of scientific information that comes from modern research instruments. Simulations allow us to run in the computer experiments that otherwise would be too expensive, dangerous, time consuming, or even impossible. Indeed, computation is joining experimentation and mathematical analysis as a basic new paradigm for how science is done.

Many next generation computer/communication systems that provide necessary government services—air traffic control, financial management and tax administration, law enforcement, and the delivery of social benefits such as health care and social security—will be enormously complex and will require new generations of advanced technology to design, implement, and operate with efficiency, safety, and reliability.

Information technology has become central to industrial growth. As an R&D tool, it underpins innovation in the so-called "high tech" industrial sectors. It provides manufacturing forms with powerful new tools for design and production; and it has become basic to the operations of many information–rich service sectors such as banking and transportation.

2. U.S. industry is facing increasingly stiff international competition for information technology products and services.

There are many reasons offered for this threat to traditional U.S. leadership in computers and communication. Surely, it must in part stem from the strong economic growth and technical sophistication of our competitors. It may also stem, in part from some past softening of support for research computing and computer science and engineering, a softening that was dramatically pointed out in the "Lax" report published in 1983, that resulted in the establishment of the Advanced Scientific Computing Program at NSF in the mid–1980's. And, we would also suggest that, to maintain our competitive edge, we must depart a bit from "business as usual" in Federal support for R&D in certain critical technologies.

3. Maintaining U.S. leadership in computing will require a major, coordinated Federal program, such as that represented by H.R. 656, that balances technological development and infrastructure building with the requisite basic research and human resource development

Advances in high performance computing in the U.S. has always benefitted from a three–way association between industrial developers, research and and engineering users, and basic computer researchers. Leading–edge users are always pushing the state of the art, demanding better systems and finding ways to get more out of the systems they have in hand. Industry attempts to create more capable systems in response to these demands.

Basic researchers in computer science and engineering explore the frontiers of computation, trying to better understand the fundamental computational nature of complex processes.

4. Basic Research is an important prerequisite to achieving the goals of any high performance computing strategy.

Although they appear in different forms in different plans, three basic objectives underlie all high performance initiatives—(1) advancing the performance state of the art in leading-edge computer systems, (2) developing new and more effective applications of high-performance computing to science and engineering, and (3) building a network based information infrastructure for the research and education community. Each of these goals poses fundamental research questions.

Most computer researchers think that to realize substantially increased computing power in the future will require developing scalable, highly-parallel systems. To achieve this, we will need research in such areas as components, packaging, and scaling concepts; computer-aided design and prototyping tools; performance measurement and benchmarking, and the development and testing of prototype systems.

To develop new applications software for research will require advances in generic software for tasks such as program parallelization, data management, visualization, and performance optimization. Advances in algorithms for specific numerical tasks also will be required.

The infrastructure, based on the gigabit network will also include a wide variety of computers, data bases, software and services. Building the network, itself, will require basic research in data communications and switching systems. More research will be needed on the applications software that will reside in the network and support the research collaboration that will take place over it.

Finally, new and fundamental research questions and opportunities in such areas as complexity theory, programming languages, algorithms, human–machine interface, and artificial intelligence will be raised by the extraordinarily complex systems we will be building.

5. Benefits of the basic research effort will reach far beyond the immediate goals of advancing high–performance computer technology and solving "Grand Challenge" research questions.

The history of computers shows that advances at the high–performance end of computer design begin very quickly to influence the main–frame and, even, the lower end machines. We can expect that, as we learn how to build and use highly parallel processors, main–frames, desk–top workstations and even personal computers will begin to incorporate these concepts.

Similarly, software techniques find their way from the research lab into an increasingly broad range of applications in industry and government.

6. Development of human resources will be a critical aspect of any high–performance computing legislation.

Although the graduate educational system is producing computer scientists and engineers. (U.S. and Canadian Universities graduated 907 new PhD's last year according to our survey), there is a serious shortage of people trained to explore the uses of high–performance computing in solving "Grand–Challenge" problems. Professor John Rice, a computer scientist form Purdue University and a member of our board, discussed computational science education in the January issue of Computing Research News. He described the problem as follows:

"Too often the computing knowledge of highly trained engineers and scientists working on [computational science and engineering (CES)] projects is at the college sophomore, or lower, level. Too often, we have highly trained computer scientists whose knowledge about engineering and sciences is at the college sophomore, or lower, level."

To address this problem, new computational science and engineering programs have been formed, but they are by and large, at the beginning stage. We will need to increase the number and level both of scientists and engineers trained in computer science and engineering and of computer scientists and engineers trained to explore the deep research questions raised by "Grand Challenge" scientific and engineering problems.

Finally, Mr. Chairman, in conclusion, I would like to point out that remarkable advances in computer science and engineering are in large part responsible for the fact that we can even dream about addressing the "Grand Challenge" problems of computational science. The research involvement of computer scientists and engineers, as well as the development of a new generation of computational scientists, will be required to achieve the short–term goals of this legislation. Equally important, an increased investment in basic research and human resources in computing is essential to maintaining our nation's competitive edge and providing the foundation for the *next* round of advances.

In short, a high–performance computing initiative, such as established by H.R. 656, is a critical investment in the nation's future. The window of opportunity for this investment, in terms of the nation's ability to maintain its leadership, is closing rapidly. The Computing Research Association strongly supports this legislation. I, and the staff and officers of CRA, stand ready to assist your committee in any way appropriate as you proceed with the development and passage of this bill.

Mr. BOUCHER. Thank you, Dr. Young.

Dr. McRae, we'll be happy to hear from you.

STATEMENT OF GREGORY J. McRAE, PROFESSOR OF CHEMICAL ENGINEERING AND PROFESSOR OF ENGINEERING AND PUBLIC POLICY, CARNEGIE MELLON UNIVERSITY, PITTSBURGH, PENNSYLVANIA

Dr. McRAE. Mr. Chairman, members of the committee, my name is Greg McRae. I'm the Professor of Chemical Engineering and Engineering and Public Policy at Carnegie Mellon University, and I really appreciate the opportunity to come before the committee and sort of offer my support for the act.

In my view, I think this act represents a truly extraordinary opportunity for the United States. The kinds of problems I'm solving now I just simply could not have done with out high-performance computers, and I'm now being able to solve problems which I just dreamt about five years ago. So I think that bringing realizable computing power to the applications community represents enormous economic benefits to the Nation as well as tremendous scientific advances.

I'd like to sort of perhaps just give you a very specific example of what I mean by that. The work that we've been conducting over the last few years at Carnegie Mellon has been to try to understand the physical and chemical processes responsible for air pollution. What we've been able to do with supercomputers is to translate that basic science into its applications in cities like Los Angeles, helping the California Air Resources Board think about alternative fuels policies. When you think in the United States that we currently spend $30 billion a year on air pollution controls and 70 percent of the population is still exposed to unhealthful air, if we could shave just 10 percent off the cost of controls, we would essentially pay for this program in three months.

I think this is just one of the grand challenges that we're talking about. I think that the numbers that Dr. Bromley spoke about this morning for the potential economic benefits to the Nation are truly extraordinary, and I think that supporting this initiative is extremely important.

I'd like to comment on a couple of issues which I think are important. One, I think, is an organizational activity. I think the fact that many of these agencies have come together cooperatively is also very, very exciting to me because it gives us a chance to think about setting priorities across many agencies and getting coordinated activities on these, so I really wish to emphasize the importance of that organizational initiative as well as getting the job done.

What I'd like to do is spend just a few moments and address some of the questions that were sent to us in the letter about specific provisions of the act, and I'd like to just discuss a couple of things.

The first one is the role of the National Science Foundation Centers. In the past five years, the National Science Foundation has supported supercomputer centers that have provided state-of-the-art access to the best possible computers and resources to literally thousands of researchers across the country. This is an absolutely extraordinarily important resource to this country, and I think it is very ironic that in the current budget the funding for these centers if essentially flat.

The National Science Foundation supercomputer centers represent the major source of people to get the job done in terms of training, in terms of education, in terms of providing the infrastructure to take risky ventures. So I would really strongly support that the National Science Foundation supercomputer centers have a critically important role to play in this initiative, and I think they should be specifically acknowledged and their importance acknowledged in the act.

I think they also represent a tremendous pool of talent which we could tap to grow this program. Getting people, I think, is the critical issue, and the National Science Foundation centers are one of the only places now with the growing State centers of actually reaching out and increasing the pool of resources of people who can actually use these resources.

The next point I'd like to touch on briefly is the focus on the grand challenges. Now, from a personal perspective, I like that because several of my research activities fall into those categories, but I think that we might be missing a really golden opportunity here by just focusing on grand challenges. There's a tremendous pool of applications out there for high-performance computing which might be, in comparison, considered to be very mundane.

I'm a chemical engineer. I like to think about how to pull chemicals apart. When you think about using supercomputers to improve the efficiency of a distillation column by 10 percent, it seems fairly boring and not really worthwhile to support an activity like that. But that's the basic way in which we make gasoline, so if we could get a 10 percent improvement in performance of some of our basic manufacturing industries, some of our basic chemical processing industries, there's an absolutely extraordinary economic potential there.

So while I'm not going to suggest that we should shift the emphasis away from the emphasis on the grand challenges, I think we should also recognize in creating this act the importance of high-performance computing to the base industries, the ordinary things. And I think also that, again, the National Science Foundation Centers have a role in actually educating industry about how to use these resources.

The next point I'd like to discuss briefly is the focus on massively parallel architectures. This is a technical point which has come up in the OSTP report, and also it's sort of implicit in the bill, but I think what we really need is a more broadbased approach than just these scaleable parallel architectures. I think we really need to do both. We need to build on our existing base of supercomputers, and we also need to think about how we can use these emerging architectures cooperatively. It's not an either/or situation; it's how can we put the bits and pieces together to do a better job.

Just to illustrate that point, at the Pittsburgh Supercomputer Center we just hooked together a Cray—an eight-processor traditional supercomputer—together with a 32,000-processor connection machine, and by combining the unique features of each of those machines, we got a factor of 50 reduction in the elapsed time beyond what we might have gotten from any one of these machines themselves. So what I would suggest is that we think about an emphasis on what might be called a heterogeneous approach to computing where we attempt to combine the strengths of the many kinds of machines that are out there.

And don't lose sight of the fact that the traditional supercomputer centers help we as applications researchers get the job done because, after all, all I really care about is solving my science problems. I really don't care what's inside the box. So it's very important to me in this transition to an environment of massively parallel architectures that we keep in sight the fact that we still need to solve problems. Programming these new machines is very difficult, very time consuming, and in many cases applications researchers will not take that risk if they can—to push up the size of the problems. So I think we need to think about a more broadbased approach to the kinds of architectures which will solve the problems.

The next issue which I think is perhaps the single most critical issue in this act and it deserves a lot more emphasis than perhaps has been given up to date, and that's the issue of people. Without people, we can't do any of these things, and I am personally very concerned about how do we get the people to use these wonderful resources and in fact get these ideas and concepts out into industry.

Coming from a university, while I thoroughly support a university-based educational program, I also think that there's an important role to help in education of industry, bringing in engineers and scientists and exposing them to what can be done with supercomputers. I think that we have this unfortunate chicken-and-the-egg situation. When you see the large investment to use these tools, people tend not to want to do them, but if you can show them in a soft way or an easy way to use these tools, and in fact you can have them go back into industry, use them, and in many cases we've seen companies actually purchase high-performance computers to actually get the job done. And so I think it's extremely important that we keep in mind not only educating the next generation of researchers, but we also devote effort and activity to getting at the regular people.

The last point I'd like to comment on is the issue of administration and management of such a program. Coordination of this kind of activity is going to be a major activity, and while I understand the critical role that's being played by the FCCSET committee, one of the things I might be a little bit concerned about in the future is how you actually manage this on a day-to-day basis; how you actually set the priorities; how you coordinate between the agencies.

And so I guess I would add my vote to an NSF environment, and the reason why I say that is that they have managed the supercomputer centers, and they have been a truly spectacular success, probably one of the most successful NSF programs. They've got the capability. They've commitment to education from high school up to industry. They have industrial affiliates programs, and I also think that they have the capabilities to interact with the agencies. So I would argue for, given the complexity of the tasks that we have to take, the need for flexibility, and the need to coordinate activities between industry, Government, and universities, that the NSF Centers—NSF provides an ideal vehicle to do that.

Mr. Chairman, in summary, I am strongly supportive of the act. I don't want you to take any of the commentary I've had on the act as in any sense lessening my belief that it's the important thing to do, and I essentially urge its passage at the earliest possible date. Since I work with supercomputers, 100 days seem like a very long time. I would like to see it as soon as possible. Thank you.

[The prepared statement of Dr. McRae follows:]

Written Statement to the House of Representatives
Subcommittee on Science, Technology andCompetitiveness

on

THE HIGH PERFORMANCE COMPUTING ACT OF 1991

by

Gregory J. McRae

Departments of Chemical Engineering and
Engineering and Public Policy
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213[1]

March 7, 1991

Mr Chairman, members of the Committee. My name is Greg McRae and I am a professor of Chemical Engineering and Engineering and Public Policy at Carnegie Mellon University in Pittsburgh, Pennsylvania. I truly appreciate the opportunity to appear before your committee in support of the The High Performance Computing Act of 1991. In my view this act represents a truly important step for the United States. My own research on understanding the sources and cause of air pollution could simply not have been accomplished without access to high performance computers. I am now tackling problems that I only dreamt about five years ago. While solving air pollution problems is one of the grand challenges I would like to spend just a few moments and describe some of the potential economic benefits of the Act. Last year the United States spent in excess of $30 billion on air pollution control during a time in which more than 70% of the population were exposed to air quality levels that exceeded the Federal Ambient Air quality Standards. The research we have been conducting using supercomputers to understand the processes occuring in the atmosphere is now being used by state and local agencies to help design cost effective control strategies. Our calculations are at the heart of the Los Angeles Air Quality Management Plan, they are being used by the State of California to develop alternative fuels policies and were used to help design some of the provisions of the new Claen Air Act. Based on our initial experience more widespread use of these supercomputer based tools will lead to reductions in the cost of controls. To put this into perspective a ten percent reduction in annual air pollution control costs would, in three months, generate savings comparable to the proposed budget allocation for the High Performance Computing Act -- and all this from just one of the grand challenges. I believe the economic benefits to the Nation and to its international competitiveness are enormous.

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[1] This statement represents the personal views of the author, not those of Carnegie Mellon University.

In short, I am very supportive of the goals and initiatives proposed in this Act. I am also very encouraged by the level of interagency collaboration and the emphasis on a balanced approach involving hardware, networks for communication, applications and people. My comments on the Act are based on my experience in using high performance computing to solve real applications problems. I would like to offer some comments in 5 areas:

- The role of the National Science Foundation Supercomputing Centers
- Whether the Grand Callenge Problems are the Right Vehicle
- The need for a mixed computing strategy
- Human Resource Issues
- Administration and Management of the program

The National Science Foundation Supercomputing Centers:
In the past five years, the National Science Foundation (NSF) supported supercomputer centers have provided state of the art access to the best possible computers and resources for thousands of research projects in every part of the country. They have provided leadership for a large number of "spin-off" centers both in the United States and abroad. In fact, the NSF programs are the envy of the world and the model of a ubiquitous high-speed network attached to a variety of very high performance computers has been imitated in many other countries. This program has been one of the most successful in the history of the National Science Foundation. It is therefore rather ironic that the high performance computing initiative in the 1992 budget contains almost no benefit for the the NSF supercomputer centers. Under the current NSF plan, the center's budget will be essentially flat. In my view this program, and its role in meeting the grand challenges, should be expanded and specifically acknowleged in the Act.

The NSF centers represents a tremendous talent and resource pool for the Nation -- they have the capability to deliver many of the requirements of the High Performance Computing Act and should receive vigorous and effective support. The centers represent the most effective way to deliver the needed performance to the widest range of researchers both in academic as well as industrial arenas.

Focus on Grand Challenges:
While I thoroughly endorse the notion of tackling the grand challenge problems posed in the Office of Science and Technology Policy report at the same time I believe that we might be missing a golden opportunity for additional economic benefits to the nation. There is a tremendous potential for the application of high performance computing in many of our more traditional manufacturing and process industries. For example, improving the operating efficiency of a distillation column by 10%, or reducing the time to market for industrial products, may seem rather mundane but when you translate these small performance improvements to reductions in the cost of producing gasoline then the economic benefits can be astronomical. Building and operating more efficient distillation columns requires a deeper understanding of the underlying physics and chemistry and the construction of more detailed mathematical models. If the models are to be useful for process control and optimization then they require the use of high performance computing in order to solve the governing equations. We have already seen the benefits of these approaches in the aircraft industry. Quite apart from enhancing the efficiency of U.S. industry more widespread use of high performance computing will also increase the maket for new computers, software products and networks.

While the Grand Challenge Problems present a strong motivation for the goals of the High performance Computing Act -- we should not ignore and indeed emphasize the benefits in more traditional areas.

The Focus on Massively Parallel Architectures:
Implicit in the Bill and the OSTP report is an emphasis on massively parallel architectures. I believe that a more broader strategy is required, one that support the the use of both traditional as well as emerging supercomputing architectures. My personal view, based on programming many different parallel architectures is that what is required is a heterogeneous approach, one where you can combine the strengths of many different types of computers. For example, at the Pittsburgh Supercomputing Center we have linked an eight processor CRAY YMP with 32,000 processor Connection Machine 2 and achieved a factor of 50 reduction in the elapsed time for solution of a complex resource scheduling problems over what could have been accomplished on either machine alone. The basis idea is to partition the applications problem into component parts and then use the best computer archtecture to solve each part. Many of the emerging massively parallel architectures are very difficult to program and frequently do not achieve anything like their rated performance on problems that have algorithmically different components parts. All applications researchers care about is performance and minimizing the elapsed time for obtaining a solution, massively parallel architectures are only attractive if they can compete with conventional supercomputers. The National Science Foundation Supercomputing

Centers represent ideal environments for maintaining these new machines because they minimize the risk to individual investigators. In summary, during the transition to scalable parallel machines applications applications researchers will continue to need support to use traditional supercomputers.

Human Resource Issues:

Perhaps the most important aspect of the High Performance Computing Act is the notion of education -- getting more people to be both aware and capable of realizing the benefits of high performance computing. Vigorous and sustained efforts are needed to educate students as well as more established industrial researchers. While I thoroughly support university based educational initiatives we should not neglect the existing talent pool in industry. In the case of industry, the traditional chicken and egg analogy is very appropriate. Unless industry can see the benefits of high performance computing they will not invest in the needed hardware and training. However without the training, industrial researchers will not be able to use high performance computers or recommend that their companies invest in new hardware, software and neworks. Again the National Science Foundation Supercomputing Centers, through their industrial affiliates programs, have played an important role by training literally hundreds of engineers in the use of high performance computing. In many cases this activity has resulted in companies purchasing their own high performance computing environments. This has produced dual benefits, improved efficiencies in industry and an increased market for supercomputer products.

Administration and Management Issues:

Coordination and management of such a large program is a major undertaking. Careful thought must be given to the mechanisms for setting priorities and, in particular, fostering links between applications researchers and computer scientists. If we are to be successful in tackling the grand challenge problems considerable effeorts need to be directed at establishing multi-disciplinary teams and projects. Unless the software initiatives, network research, and computer architecte developments are directly linked to applications needs the program will not be successful. There is ample historical evidence to suggest that it is easy to build a computer -- the real test is getting people to use the machines to solve demanding applications problems.

Summary:

Mr chairman, as I said at the outset I am very supportive of the Act and I believe it will be of great benefit to the nation. I urge its passage at the earliest possible date.

- BRIEF BIOGRAPHICAL SKETCH -

Gregory J. McRae

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Gregory J. McRae is a Professor at Carnegie Mellon University and holds a joint appointment between the departments of Chemical Engineering and Engineering and Public Policy. He joined CMU in 1983 after receiving a Ph.D. in Engineering from the California Institute of Technology (Caltech). A major focus of Professor McRae's research is understanding the scientific aspects of problems involving pollutant transport and transformation in multimedia environments. His other interests include: combined sensitivity and uncertainty analysis of complex systems, nonlinear parameter estimation, combinatorial optimization, numerical analysis, symbolic and algorithmic knowledge based systems, parallel computing, and the design of cost effective, robust environmental controls.

Professor McRae is the recipient of numerous prizes and awards for his research in environmental and computational science including: the prestigious Presidential Young Investigator Award, the George Tallman Ladd Research Prize, an AAAS Environmental Science Fellowship and the 1989 Forefronts of Computational Science Award. He is a member of Sigma Xi, the American Chemical Society and the American Institute of Chemical Engineers. In addition, he is also on the editorial board of the International Journal of Supercomputer Applications, the advisory committee for the Pittsburgh Supercomputing Center and several government and White House Task forces on environmental issues. He has been a visiting scientist at the National Center for Atmospheric Research, the U.S. Environmental Protection Agency and the IBM T.J. Watson Research Center.

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Mr. BOUCHER. Thank you, Dr. McRae.
Mr. Rottsolk?

STATEMENT OF JAMES E. ROTTSOLK, PRESIDENT AND CHIEF EXECUTIVE OFFICER, TERA COMPUTER COMPANY, SEATTLE, WASHINGTON

Mr. ROTTSOLK. Mr. Chairman and members of the committee, thank you for inviting me to appear before you today.

My name is James E. Rottsolk, and I am President of Tera Computer Company, a Seattle-based company. Tera was founded in 1987, and since 1988 has been supported by DARPA. Our mission is to develop the next generation supercomputer. Our first product, which will be available in 1993, will be capable of performing at 300 gigaflops per second, or 100 times faster than today's fastest supercomputers. Subsequent implementations of our scalable parallel system will be capable of exceeding a teraflop—that is, a trillion operations per second—by the middle of the decade.

I wish to commend this committee for its continued interest and support for a national high-performance computing plan. Our earlier testimony before this committee and others in support of the High-Performance Computing Program has focused on the importance of both the development and the acquisition of prototype and preproduction versions of innovative new parallel computer systems. I am happy to see that the legislation before us today contains provisions that accomplish these goals.

The High-Performance Computing Act of 1991 offers the best potential to strengthen our national competitive position. Without high-performance computing and appropriate networking technologies, we will be unable to meet the grand challenge problems whose solutions are critical to our national needs. I would like to address the remainder of my remarks to a few specific points regarding the bill before the committee today.

H.R. 656 requires the President to develop and implement a national high-performance computing plan. I would suggest that that plan, the Grand Challenges plan, has been presented and fulfills this goal. I would urge this committee to incorporate this plan or large portions of it by reference and adopt its provisions. Doing so will allow for immediate implementation of a well coordinated research and development program that will sustain U.S. leadership in this high technology area.

Nearly always, customers for the first few years of production of each new supercomputer have been Government agencies; specifically, DOD, DOE, and NASA, and more recently, through the supercomputing research centers, the National Science Foundation. Prototype development of promising systems on a cost-sharing basis is one of the best examples of industry/Government cooperation. The development of high- performance computer systems requires long term projects with an integrated approach involving both software and hardware design. Particularly with respect to large scale parallel systems, it would be inappropriate not to emphasize the significant importance of software design as an integral part of the overall development.

Prototype acquisition is sufficiently important to user agencies and to our industry that I would urge this committee to consider incorporating what is now section 4(b) of H.R. 656 into section 701 of the National High-Performance Computing Program itself. Acquisition of prototype or early production models of new high-performance computer systems should be a natural and integral component of such a program.

The Federal High-Performance Computing Program issued by OSTP in 1989 recommended a five-year funding plan. The funding was to be incremental over existing levels. Developers of both hardware and software, because they need the continuity provided by a multi-year plan, need to be able to plan on this continuity if they are to establish their programs. My reading of the bill before us is that it does require a five-year funding plan. However, the plan presented by the FCCSET committee contains only incremental funding in fiscal year 1992 and states what the base level funding was in 1991. I would suggest that this plan be supplemented, if it's accepted, with the five-year numbers themselves.

I hope that the National Research and Education Network will continue to be seen only as one component of the entire High-Performance Computing Program. The several components taken as a whole—hardware development, software development, the network, and education—will meet the responsibility this Nation has to protect U.S. technological leadership. If any of these elements are neglected, I fear the plan will fail to meet its full potential.

As the High-Performance Computing and Communications Plan states, the program must achieve sufficient scope and balance among the components. A technology program that created extremely fast processors without comparable memory systems would not succeed. Neither would a program that created powerful computers without adequate software, network access, and capable people. Similarly, a program that created only high-performance networks would not satisfy the increased performance requirements needed for grand challenges.

Finally, allow me to conclude my comments with a quote from a November 1985 White House Science Council report, "Research in Very High-Performance Computing," which stated, "The bottom line is that any country which seeks to control its future must effectively exploit high-performance computing. A country which aspires to military leadership must dominate, if not control, high-performance computing. A country seeking economic strength in the information age must lead in the development and application of high-performance computing in industry and research." I believe we share these objectives and would urge implementation of the high- performance computing plan. Thank you very much.

[The prepared statement of Mr. Rottsolk follows:]

Statement of James E. Rottsolk

President and Chief Executive Officer

Tera Computer Company

before the

House Subcommittee on Science

and the House Subcommittee on Technology and Competitiveness

of the

Committee on Science, Space and Technology

United States House of Representatives

March 7, 1991

Mr. Chairmen and Members of the Committee, thank you for inviting me to appear before you today to testify on behalf of H.R. 656, the High Performance Computing Act of 1991.

My name is James E. Rottsolk and I am President and CEO of Tera Computer Company located in Seattle, Washington. Tera was founded in 1987, and has been supported by the Defense Advanced Research Projects Agency (DARPA) since 1988. Our corporate mission is the development of the next generation supercomputer. Tera's first product, available in 1993, will be capable of performing up to 300 gigaflops per second, more than 100 times faster than today's supercomputers. Subsequent implementations of our scalable parallel system will be capable of exceeding a teraflop, or one trillion operations per second, by the mid-1990's. With adequate funding support and an improved technology infrastructure, we will see microprocessors based on our computer and performing several billion operations per second before the end of the decade.

I wish to commend this Committee for its continued interest and support for a national high-performance computing plan.

Tera has been actively involved in securing implementation of a national high-performance computing plan since the OSTP Report: "The Federal High Performance Computing Program", was initially released. We testified in support of that Program and directed most of our comments to the importance of the development and acquisition of prototype and pre-production versions of innovative new parallel computer systems. I am happy to see that the legislation before us today incorporates provisions to accomplish these goals.

The United States has for many years enjoyed a position of technological and industrial superiority in many areas, but this has been particularly true in the supercomputer field. Leadership, however, is not a constant. It is a fragile position that, without nurturing, can be easily given to other nations.

America's supercomputer industry stands on very unsteady ground. One supercomputer company has closed and another has split, leaving Cray Research, Inc. and a few new firms including Tera Computer Company. A national failure in supercomputing is a very real possibility unless our federal government implements a thoughtful plan of action to provide the necessary funding and the interagency and interdisciplinary cooperation and synergy that will enable these technologies to be proven.

The High Performance Computing Act of 1991 offers the best potential to strengthen our national competitive position both directly, by the development of both hardware and software for high speed computing, and indirectly, by the new research, product development and manufacturing that are made possible by these fast computers.

We can ill afford to neglect supercomputing. Supercomputing is an enabling technology that leads to greater industrial productivity. Supercomputers enable researchers to solve problems in engineering and science heretofore thought to be unsolvable. They have transformed the way products are designed and manufactured and have greatly reduced the cost to industry and government of new product development.

High performance computing, along with a sophisticated, high speed computer network to provide access to such a resource, is vitally important to scientific advancement, economic strength and national security. Without high-performance computing and networking technologies we will be unable to meet the grand challenge problems whose solutions are critical to national needs.

A balanced, programmatic approach such as that represented in H.R. 656 has capacity to bolster America's leadership in the economic, industrial, and technological marketplace. Federal investment in science and technology projects often fall prey to competing special interests, resulting in continued funding for the high profile projects and continued neglect of the many less visible projects critical to maintaining America's technological superiority. The high-performance computing program represents an integrated approach to research and technology development, technology transfer and research cooperation, and education and training. To fund this program is to fund scientific advancement across a broad front.

At this point, I would like to address the remainder of my remarks to some specific thoughts on the bill before the Committee today.

1. H.R. 656 requires the President to "...develop and implement a National High-Performance Computing Plan...". Such a Plan has been submitted and I urge this committee to incorporate the Plan by reference and adopt its provisions. Doing so will save us the additional year that is called for in H.R. 656 and allow for immediate implementation of a well-coordinated research and development program that will sustain U.S. leadership in advanced computer technology.

The Plan, entitled: "Grand Challenges: High Performance Computing and Communications," prepared by the Committee on Physical, Mathematical, and Engineering Science, the Federal Coordinating Council for Science, Engineering and Technology, and the Office of Science and Technology Policy is not primarily a White House plan. It is the result of several years of effort by government, industry and academia and represents a comprehensive and interdisciplinary program involving the participation of DOD, NASA, NSF, DOE, NOAA, NIH, EPA and others.

In September 1989, the Executive Office of Science and Technology Policy issued a report entitled, "The Federal High Performance Computing Program," which outlined steps for preserving this nation's preeminence in high speed computing. It bears noting that this was not the first attempt at initiating a national high-performance computing plan. In November, 1987, the Office of Science and Technology Policy issued a report entitled, "A Research and Development Strategy for High Performance Computing", which itself was the culmination of studies begun in 1983.

2. Nearly always, the customers for the first few years of production of each new supercomputer have been government agencies, specifically DOD, DOE, NASA and, more recently, NSF. It is impossible for a supercomputer company to exist without government customers. Prototype development of promising systems on a cost-sharing basis is one of the best examples of industry-government cooperation.

Prototype acquisition is necessary but not sufficient; the Program should also support both basic research and the development of innovative new supercomputers and the software required to utilize these systems efficiently. The development of high performance computer systems, nearly all of which we expect to be scalable parallel systems, are long term projects requiring an integrated approach involving both hardware and software design. New computer architectures must be designed to allow software to harness their full power. Access to these new computing resources by a larger community will accelerate the availability of applications software.

In today's economic situation, both federal and industrial budgets are tight. Early acquisition of innovative prototype systems provides vital financial support to the supercomputer enterprises in the development stage, while ensuring that the completed system responds to significant agency missions.

The importance of prototype acquisition is of such importance to these agencies and to our industry that I would urge this committee to consider incorporating what is now Section 4 (b) of H.R. 656 into Section 701 of the National High-Performance Computing Program itself. Acquisition of prototype or early production models of new high-performance computer systems should be a natural and integral component of such a program.

3. The "Federal High Performance Computing Program" issued by OSTP in late 1989 recommended a five-year funding plan. The funding was to be incremental over existing levels. Developers of both hardware and software need to be able to plan on a continuity of funding if they are to establish the necessary multi-year programs. I would suggest that the legislation more specifically require a five-year funding plan. The current Plan only contains base 1991 funding and incremental recommendations for fiscal 1992.

4. I recognize the important role that a national computer network will play in facilitating technology transfer, providing access to researchers, and enabling the synergy necessary between researchers, academicians and students in order to meet the Grand Challenges that confront us today. However, I hope that the National Research and Education Network will continue to be seen as only one component of the entire high-performance computing program. The several components taken as a whole will meet the responsibility this nation has to protect U.S. technological leadership. If any are neglected, the Plan will fail to meet its full potential. As is stated in the High Performance Computing and Communications Plan: "The program must achieve sufficient scope and balance among the components. A technology program that created extremely fast processors without comparable memory would not succeed. Neither would a program that created powerful computers without adequate software, network access, and capable people. Similarly, a program that created only high-performance networks would not satisfy the increased performance requirements needed for grand challenges."

I would like to conclude my comments with a quote from a November, 1985, White House Science Council report, "Research in Very High Performance Computing," which stated: "The bottom line is that any country which seeks to control its future must effectively exploit high-performance computing. A country which aspires to military leadership must dominate, if not control, high-performance computing. A country seeking economic strength in the information age must lead in the development and application of high-performance computing in industry and research."

I believe these are objectives of the United States and as such, it is imperative that the National High Performance Computing Plan be implemented now. I thank you Mr. Chairman and Members of the Committee and am prepared to respond to any questions you may have.

Mr. BOUCHER. Thank you, Mr. Rottsolk.

Dr. Lee, we'll be happy to hear from you, and your very esteemed Congressman and the Co-Chairman of this hearing, Mr. Valentine, expresses his regrets at not being able to be here at the moment. As we speak, he's handling an amendment on the floor of the House to the Supplemental Appropriations Bill and for that reason wasn't able to be with us. We'll be happy to hear your comments.

STATEMENT OF LAWRENCE A. LEE, EXECUTIVE DIRECTOR, NORTH CAROLINA SUPERCOMPUTING CENTER, RESEARCH TRIANGLE PARK, NORTH CAROLINA

Dr. LEE. Thank you, Mr. Chairman. I'm sure that's very important.

I'm very honored and pleased to have the opportunity to address this committee and comment on the proposed High- Performance Computing Act of 1991. To begin, let me thank the members of the House Committee on Science, Space, and Technology for your very strong support in recent years of the National Science Foundation and science programs in other agencies.

The establishment of the National Science Foundation supercomputing centers in 1985 and the NSFNET in 1987 have led to the creation of a national infrastructure in scientific communications and computing that has created important university/industry/Government/research partnerships. In my personal experience as a collaborator involved in such partnerships at two centers, the Cornell Theory Center and the North Carolina Supercomputing Center, I can point to a number of achievements that occurred because of strong university/industry/Government cooperation. It is this type of cooperation that is necessary for the U.S. to maintain leadership in high-performance computing technology and its application to grand challenge problems.

This particular bill is excellent. I do wish to discuss several points. Number one, the role of high-performance computing in corporate research. Today, high-performance computing is becoming a vital component of scientific investigation for many areas of research in American industry.

For example, in the design of materials, an understanding is needed of the fundamental nature of the transition from a collection of atoms to a macroscopic system with different characteristics and behavior. A single corporation cannot easily invest the $10 million to $15 million needed to initiate its own supercomputing center until it has experienced the benefits. Small companies are unable to make such an investment in this technology even if they understand the advantages. Furthermore, there is a scarcity of trained scientists and engineers in high-performance computing for corporations to draw upon.

What is needed is a step-by-step program to encourage corporations to share the resources of high-performance computing centers. The resources include education, training, availability of high-performance computing over networks, and access to expertise in computational science. Introducing high-performance computing technology into corporate research and development will fundamentally change the way industrial research is conducted and will have a long term, far-reaching impact on competitiveness.

It is important to note that Japan's industry has been aggressive—very aggressive—in utilizing high-performance computing in product design, prototype testing, production simulation, and continuing product refinement. A frightening example of this is the fact that the average Japanese automobile manufacturer has a design-to-product-cycle time now of approximately 28 months, while the average American automobile company requires 54 months for the same task.

The next point I would like to talk about is the role of networks in high-performance computing. Networking has quickly become one of the most critical resources in this electronic age. Today, the national network delivers high- performance computing capabilities to researchers Nation-wide and thus leverages scarce resources, human as well as facilities. The rising costs of these resources, coupled with the ever-accelerating advances in science, technology, and knowledge, demand a more capable national network and one whose service is extended to the educational and library communities.

Increases in capacity and speed will bring new and innovative uses of networking, some of which we can't even imagine today. VistaNet, a cooperative university/industry supercomputing project in North Carolina, is one of five national gigabit test beds. It is designed to experiment with the use of high-performance computing and very high-speed networking for radiation treatment of tumors. The experiment involves sending CAT scan images over a very high-speed network to a remote supercomputer for analysis in order to more accurately target radiation beam treatments on tumors in real time.

In the next development of this network, the next stage of the development of this network, I recommend that the Government experiment with interactive video capabilities. This would allow, for example, highly specialized university courses to be made available to students at other universities who would not normally have access to such courses. This would also provide a very conducive environment for research collaboration among geographically dispersed scientists. Such an advanced network exists in North Carolina. It links 11 universities, three medical schools, and the North Carolina Supercomputing Center.

The third point: the role of States in the Federal High- Performance Computing and Communications Program. In the last three to five years, individual States have greatly increased their participation in high-performance computing. They have contributed to the development and advancement of the national network. And more than 20 States have now created high-performance computing centers.

For example, the State of North Carolina invests $12.5 million per year in the North Carolina Supercomputing Center and Concert, the advanced State-wide network. I estimate that this is the largest or one of the largest State-supported high-performance computing and communications programs in the Nation. The State has made this commitment to high-performance computing in the belief that it will accelerate the advancement of academic and corporate research and will greatly enhance education. It is important to note that North Carolina has made this enormous investment while being the lowest State in receiving per capita Federal dollars.

The Federal Government is involved in high-performance computing in North Carolina at $2.5 million per year through EPA, DARPA, and NSF. In the North Carolina Supercomputing Center's cooperative agreement with EPA, we are seeking a more efficient way of developing and executing several environmental models and analyzing their results.

Alongside the pioneering leadership of the National centers, State centers have been very effective in transferring the use of this technology to academic and industrial institutions within their boundaries. The Federal Government needs to encourage the forging of cooperative activities across State boundaries. Problems of a regional scope—ecological, environmental, agricultural, biomedical, econometric, and geological—need addressing.

The development and use of regional models to investigate air quality, climate changes, coastal/ocean dynamics, and economic trends are examples of critically important efforts that require vast amounts of high-performance computing resources and well established training programs on the application of hardware, software, networks, and visualization techniques to these problems. I urge that the Federal Government support existing centers to incorporate multi-State/regional programs in high-performance computing. This will lead to a greatly strengthened and more tightly coupled national program in high-performance computing.

Point number four: emerging high-performance computing technologies. Having invested in high-performance computing in the 1980s through NSF, DOE, DARPA, and NASA programs, the Federal Government must continue to support research on high-performance computing technology. In my view and based on my experience, special emphasis needs to occur on more advanced parallel systems, mass store systems, the advancement of visualization and imaging analysis tools, cooperative distributed computing, and the networking integration of heterogeneous systems.

The next step needed is the transfer of emerging high- performance computing technologies, such as scaleable parallel systems, to centers and other application environments so that they are available for exploratory use by industry, education, and research. Centers will very naturally encourage the mapping of numerical algorithms to appropriate computer architectures and problems to appropriate computers and bring parallelism into production use through efforts, among others, in encouraging the development of software tools.

Point number five: the role of high-performance computing in education. The Nation is faced with the need for a much larger pool of scientists and engineers and the need to greatly improve the scientific, technological, and computational literacy of the general public. Our competitiveness and future productivity depends upon a much greater—excuse me—a much larger work force with computational skills and scientific expertise.

High-performance computing has changed the way in which scientific research is conducted. Visualization, for example, has enabled scientists to develop graphical representations of complex scientific processes. High-performance computing is now ready to be transferred to education. It will have both an invigorating and bolstering effect on education. It will empower the teachers with sophisticated and meaningful tools for classroom and laboratory work, and it will give students opportunities to explore, experiment, and discover.

The Federal Government, through the proposed bill, should stimulate a Nation-wide effort to incorporate the use of high-performance computing technology in the classroom at all educational levels. The focus of such a program should be on training teachers and faculty, connecting schools and colleges to NREN, developing and distributing instructional material and tools for classroom use, and integrating computational science into the science and engineering curricula.

High-performance computing centers are well suited for participating in this. Through a network of mathematics and science educators in the universities, together with their contacts at all levels in local schools systems, centers can spearhead a broadbased educational initiative to transfer high-performance computing technology to science, engineering, and mathematics education.

In summary, I strongly support the proposed bill and urge that the Government; one, encourage industry to share access to resources at high-performance computing centers; two, expand the network, adding new capabilities and new resources; three, incorporate State and regional high-performance computing programs into the national program; four, transfer emerging high-performance computing technologies into application environments, such as centers and universities; and five, foster the inclusion of high-performance computing into education.

I would be most happy to expand on any of these points. Thank you very much.

[The prepared statement of Dr. Lee follows:]

A PERSPECTIVE ON THE PROPOSED HIGH PERFORMANCE COMPUTING ACT OF 1991

Testimony Delivered by
Lawrence A. Lee
North Carolina Supercomputing Center, Research Triangle Park, NC
Before the House Committee on Science, Space, and Technology
Thursday, March 7, 1991

I am very honored and pleased to address this committee and comment on the proposed "High Performance Computing Act of 1991". To begin, let me express my thanks to the Members of the House Committee on Science, Space and Technology for your strong support in recent years of the National Science Foundation.

In my view, the federal High Performance Computing and Communications (HPCC) program is fundamentally important to maintaining US leadership in developing this technology and in applying it to the requirements of government, industry, and academia.

Many of the complicated questions that society is asking scientists and engineers today are being addressed, not just by applying the traditional tools of research - laboratory experimentation or theoretical analysis - but also through the use of mathematical models on advanced computers. High performance computing is revolutionizing the way in which research is being conducted. For example, five-day and longer-range weather predictions have improved in recent years through the development and application of forecasting models on supercomputers. In the design of new aircraft, the number of expensive prototypes that need to be built and studied has been greatly reduced by the development and study of computational aircraft models running on supercomputers. These are examples of grand challenges - interdisciplinary problems of major national importance. Other examples are the study of global climate changes, mapping the human genome, and determining the strength and nature of molecular bonds. Today high performance computing centers around the nation are drawing researchers together from many different disciplines to collaborate on challenging real-world problems, and these centers are on the forefront of demonstrating exciting new ways of teaching and studying science, engineering, and mathematics.

The establishment of the National Science Foundation (NSF) supercomputing centers in 1985 and the NSFnet in 1987 have led to the creation of a national infrastructure in scientific communications and computing that has created important university/industry/government research partnerships. In my personal experience as a collaborator involved in such partnerships at two centers, the Cornell Theory Center and the North Carolina Supercomputing Center, both centers can point to a number of achievements that occurred because of strong university/industry/government cooperation. It is this type of cooperation that is necessary for the US to maintain leadership in high performance computing technology and its application to grand challenge problems.

This particular bill is excellent. I do wish to discuss several points.

(1) The role of high performance computing in corporate research.

Today, high performance computing is becoming a vital component of scientific investigation for many areas of research in American industry. For example, in the design of materials, an understanding is needed of the fundamental nature of the transition from a collection of atoms to a macroscopic system with different characteristics and behavior.

More specifically, the chemical and pharmaceutical industry needs to understand the mechanism by which proteins fold to yield a particular medical function while minimizing side-effects. The understanding of polymers and the process of polymerization is crucial to the formation of new lightweight, strong products. The behavior of thin films (down to a few atoms in thickness) is important to future development of solid state devices. Understanding the interaction of low and high temperature plasmas with materials will lead to new methods of surface etching, machining and altering material composition. On a more fundamental level of science, the understanding of the physical processes governing the crystal structure and the electrical magnetic properties of high temperature superconductors is necessary for developing an application technology for these compounds. All of these problems require access to the most capable high performance computers and to advanced visualization techniques.

A single corporation will not invest the $30M or so required to initiate its own supercomputing center in high performance computing until it has experienced the benefits. Small companies are unable to make such an investment in this technology, even if they understand the advantages. Furthermore, there is a scarcity of trained scientists and engineers in high performance computing for corporations to draw upon. What is needed is a step-by-step cooperative program between high performance computing centers and corporations that includes education, training, availability of high performance computing resources over networks, and access to expertise in computational science. Introducing HPCC technology into corporate research and development will fundamentally change the way scientific and engineering research is conducted and will have a long-term far reaching impact on competitiveness.

(2) The role of networks in high performance computing.

Networking has quickly become one the the most critical resources in this electronic age. Today the national network delivers high performance computing capabilities to researchers nationwide and thus leverages scarce resources (human as well as facilities). The rising costs of these resources, coupled with the ever accelerating advances in science, knowledge, and technology, demand a more capable national network and one whose service is extended to the educational and library community.

Increases in capacity and speed will bring new and innovative uses of networking. Some of which we can not even imagine today. VistaNet, a cooperative networking, supercomputing, university, and industry project in North Carolina, is one of five national gigabit testbeds. It is designed to experiment with the use of high performance computing and very high speed networking for radiation treatment of tumors. The experiment involves sending catscan images over a very high speed network to a remote supercomputer for analysis in order to more accurately target radiation beam treatments on tumors in real time.

In the next development stage of the network, I recommend that the government experiment with interactive video capabilities. This would allow, for example, highly specialized university courses to be made available to students at other universities who would not normally have access to such courses. This would also provide a very conducive environment for research collaboration among geographically dispersed scientists. Such an advanced network exists in North Carolina. It links 11 universities, three medical schools, and the North Carolina Supercomputing Center.

(3) The role of states in the Federal High Performance Computing and Communications program.

In the last three to five years, the states have greatly increased their participation in high performance computing. They have contributed to the development and advancement of the national network and more than 20 states have now created high performance computing centers. For example, the state of North Carolina invests $12.5 million per year in the North Carolina Supercomputing Center and Concert, the advanced state-wide network. I estimate that this is the largest or one of the largest state-supported high performance computing and communications programs in the nation. The state has made this commitment to high performance computing in the belief that it will accelerate the advancement of academic and corporate research and will greatly enhance education. It is important to note that North Carolina has made this enormous investment while being the lowest state in receiving per capita federal dollars.

The federal government is involved in high performance computing in North Carolina at $2.5 M per year through EPA, DARPA, and NSF. For example, in the NCSC cooperative agreement with EPA, we are seeking a more efficient method of developing and executing several environmental models and analyzing model results. One such model is the Regional Acid Deposition Model (RADM). The RADM takes meteorological and pollutant emissions data and estimates the concentrations of chemical pollutants in the atmosphere. EPA and NCSC are also investigating the application of advanced scientific visualization techniques in enhancing the interpretation and evaluation of massive amounts of environmental and simulation data. In the months ahead, EPA and NCSC will commence a study on the effectiveness of certain computational methods and algorithms on alternative architectures.

Along side the pioneering leadership of the national centers, state centers have been very effective in transferring the use of this technology to academic and industrial institutions within their boundaries. The federal government needs to encourage the forging of cooperative activities across state boundaries. Problems of a regional scope - ecological, environmental, agricultural, biomedical, econometric, and geological -- need addressing. The development and use of regional models to investigate air quality, climate changes, coastal dynamics, and economic trends are examples of critically important efforts that require vast amounts of high performance computing resources and well-established training programs on the application of hardware, software, networks and visualization techniques to these problems. I urge that the federal government support existing centers to incorporate multi-state/regional programs in high performance computing. Such regional centers would facilitate the use of high performance computing to address local, state, and regional challenges by fostering collaborative research, transferring technology, building applications, creating regional databases, and advancing networking capabilities. This will lead to a strengthened and more tightly-coupled national program in high performance computing.

(5) Emerging technologies.

Having invested in high performance computing in the 1980's, through NSF, DOE, DARPA, and NASA programs, the federal government should continue to support research on high performance computing technology. For example, special emphasis needs to occur on more advanced parallel systems, mass store capabilities, the advancement of visualization and imaging anaylsis tools, cooperative distributed computing, and the network integration of heterogeneous systems.

The next step needed is the transfer of emerging HPCC technologies such as scalable parallel systems to centers and other application environments so that they are available for exploratory use by industry, education, and research. Centers will very naturally encourage the mapping of numerical algorithms to appropriate architectures and problems to appropriate platforms and bring parallelism into production use through efforts, among others, in encouraging the development of software tools.

(4) The role of high performance computing in education.

The nation is faced with the need for a much larger pool of scientists and engineers and the need to greatly improve the scientific, technological, and computational literacy of the general public. Our competitiveness and future productivity depends upon a much larger workforce with computational skills and scientific expertise.

High performance computing technology has changed the way in which scientific research is conducted. Visualization, for example, has enabled scientists to develop graphical representations of complex scientific processes. High performance computing is now ready to be transferred to education. It will have both an invigorating and bolstering effect on education. It will empower the teachers with sophisticated and meaningful tools for classroom and laboratory work and it will give students opportunities to explore, experiment, and discover.

The Federal government, through the proposed bill, should stimulate a nationwide effort to incorporate the use of HPCC technology in the classroom at all educational levels. The focus of such a program should be on training teachers/faculty, connecting schools and colleges to NREN, developing and distributing instructional material and tools for classroom use, and integrating computational science into the science and engineering curricula.

High performance computing centers are well suited for participating in this. Through a network of mathematics and science educators in the universities together with their contacts at all levels in local school systems, centers can spearhead a broad-based educational initiative to transfer HPCC technology to science, engineering, and mathematics education.

In summary, I strongly support the proposed High Performance Computing Act of 1991 and urge that the government (i) encourage cooperative programs between high performance computing centers and industry, (ii) expand the network, adding new capabilities and new resources, (iii) incorporate state and regional high performance computing programs into the national program, (iv) transfer emerging high performance computing technologies into application environments, such as centers and universities, and (v) foster the inclusion of high performance computing into education.

I would be most happy to expand on these points or be available for questions or help on this critically important program.

Mr. Boucher. Thank you, Dr. Lee, and the Chair extends thanks to all of the panel members for their testimony.

I have only one question. Dr. McRae has answered it already in his presentation; I'd like to ask the other three panel members about their views of the need for a lead agency for day-to-day network management, and if they have an opinion that one is necessary, their particular candidate for that role.

Dr. Young, would you care to comment?

Dr. Young. Well, the NSF has a long history of serving a diverse constituency. It's done it well. It seems to me that that record merits their playing lead agency.

Mr. Boucher. Thank you, sir.

Mr. Rottsolk?

Mr. Rottsolk. I think I would defer to the other panel members. We're not a major user as an industrial member of supercomputing research centers. Maybe we will be in the future. I would like to see that day. So I'm not certain we have a good answer, although the National Science Foundation, in our opinion, has been a good manager of the present system.

Mr. Boucher. Dr. Lee?

Dr. Lee. The National Science Foundation does have in its mission the advancement of scientific research and education. They established the NSFNET in the late 1980s and did a very successful job of connecting universities and scientists to the network, and I think they're the appropriate leader for the future.

Mr. Boucher. Thank you very much.

I would be pleased to recognize the gentleman from California, Mr. Packard.

Mr. Packard. I have two brief questions. One, as computer technology has emerged over the last two or more decades, computer security has become an increasing problem. This is the development of a broadbased, highly technical which eventually we hope will become a significantly commercial program. Will we see new and increased problems as it relates to computer security?

Dr. Young?

Dr. Young. Yes, of course. But at the same time, we'll see new solutions, and I don't think those problems are sufficiently difficult that they should stop us from going ahead.

Mr. Packard. General agreement?

Second question, a little bit the same: the protection of intellectual properties. This also makes intellectual properties much more accessible, this system would. Both nationally, and I presume internationally, a lot of international corporations will develop the system to accommodate their international communications systems in a variety of other ways. What kind of problems will we run into in the protection of intellectual property?

Dr. McRae, go ahead.

Dr. McRae. I actually have several views on the issue of intellectual properties, and that's a major concern in a university environment, but one of the things that's interesting to ask is what is it that you're concerned about? Is it the idea or the use of the idea? And I think that having access to the idea is good; what we really need to do is think about how we can increase the utilization of those ideas. So I'm not particularly concerned about issues associated with intellectual properties. We may have to rethink the way in which we thought about copyrights or what exactly is being transferred, but I don't see any personal problems with that.

It's like the equivalent of patents. The major protection comes from, you know, how you actually use the idea, not the patent itself.

Mr. PACKARD. I think that's where my question is directed. Knowing that Japan and other countries do a very good job of marketing and profiting from information that often they get from us or from other sources, and we don't do such a good job in commercializing our patents and our information, will that problem be increased with this system?

Dr. McRAE. I think one of the reasons why I place so much emphasis on education is that we need to increase the pool of people who can actually use the ideas, actually read the paper and turn them into commercial products. I find from my own journal articles when I read them I get many more reprint requests from Japan than I do from commercial companies in the United States. That doesn't mean to say that there aren't people here capable of using it, but they are much more aggressive in terms of taking the idea and actually putting it into practice.

So if we want to reverse that trend, what we have to do is to think about how to get more people involved in using and thinking about these ideas, and I believe that high- performance computing is one way to facilitate making that happen more quickly. We have an extraordinary infrastructure in the United States, and if we can just capture that to work on some of these base processes, I think we can reverse that trend.

Mr. PACKARD. I think that's sufficient. Thank you very, very much. I appreciate it.

Mr. BOUCHER. The Chair thanks the gentleman and again extends thanks to the members of this panel. We appreciate your thoughts, and we'll certainly take your recommendations into account as we structure this legislation.

This hearing of the joint subcommittees stands adjourned.

[Whereupon, at 1:35 p.m., the subcommittees adjourned, to reconvene at the call of the Chair.]

APPENDIX

ASSOCIATION OF RESEARCH LIBRARIES

March 11, 1991

The Honorable Rick Boucher
Chairman, Subcommittee on Science
Committee on Science, Space, and Technology
2319 Rayburn House Office Building
Washington, D.C. 20510

Dear Representative Boucher:

The enclosed statement is submitted in support of H.R. 656, on which your Subcommittee recently conducted a hearing. Please include the statement in the hearing record on behalf of the Association of Research Libraries. We appreciate the opportunity to provide the views of the Association.

Sincerely,

Duane E. Webster

Duane E. Webster
Executive Director

Enclosure

1527 New Hampshire Avenue, N.W., Washington, D.C. 20036
202-232-2466 FAX 202-462-7849

ASSOCIATION OF RESEARCH LIBRARIES

Statement of the Association of Research Libraries
to the
Subcommittee on Science, and the Subcommittee on Technology and Competitiveness
House Committee on Science, Space, and Technology
for the Hearing Record of March 7, 1991
on H.R. 656 - The High Performance Computing Act of 1991

The Association of Research Libraries is a non-profit Association of 119 research libraries in North America. The membership of ARL is actively involved in the provision of information resources – including those that are unique, to the research and education communities of North America. Research libraries also are key participants in numerous experiments and pilot programs that demonstrate the utility of high capacity networks for the exchange and use of information. ARL supports the passage of legislation that will promote the development and use of expanded networking capacities and capabilities to advance education and research.

The need for a high-speed computer communications network is a reflection of a number of changes underway in the academic and library communities. Three of these changes include the need to connect researchers with facilities such as supercomputers, databases, and library resources; the changing manner in which scholars and researchers communicate; and finally, the ability of these researchers to manipulate and combine large data sets or files in new ways only possible through connecting users with high-speed, high-capacity networks.

The NREN, the vision of the next generation network designed to support the work of the education and research communities – must reflect the changes noted above as well as those efforts already underway that address the new uses of information, while at the same time, address the national goals of improving our Nation's productivity and international competitive position. To realize these goals and to build upon existing efforts, ARL with others in the education community support the inclusion of the following points in NREN legislation. These points build upon existing successful federal, state, and local programs that facilitate access to information resources.

NREN authorizing legislation should provide for:

- Recognition of education in its broadest sense as a reason for development of the NREN;
- Eligibility of all types of libraries to link to the NREN as resource providers and as access points for users;
- A voice for involved constituencies, including libraries, in development of network policy and technical standards.

NREN legislation should authorize support for:

- High capacity network connections with all 50 states;
- A percentage of network development funds should be allocated for education and training;
- Direct connections to the NREN for at least 200 key libraries and library organizations and dial-up access for multi-type libraries within each state to those key libraries. Prime candidates for direct connections include:

*The three national libraries (Library of Congress, National Agricultural Library, National Library of Medicine) and other federal agency libraries and information centers;

*51 regional depository libraries (generally one per state) which have a responsibility to provide free public access to all publications (including in electronic formats) of U.S. government agencies;

*51 state library agencies (or their designated resource libraries or library networks) which have responsibility for state-wide library development and which administer federal funds;

*Libraries in geographic areas which have a scarcity of NREN connections;

*Libraries with specialized or unique resources of national or international significance;

*Library networks and bibliographic utilities which act on behalf of libraries.

The National Science Foundation, through its various programs, including science education, should provide for:

- The inclusion of libraries both within and outside of higher education and elementary/secondary education as part of the research and education support structure;
- Education and training in network use at all levels of education;
- Experimentation and demonstrations in network applications.

The information infrastructure of the United States is a complex conglomeration of public and private networks, institutions, information resources, and users from educational, research, library, and industrial communities with extensive ties to international networks and infrastructures. Research libraries and the resources that they acquire, organize, maintain, and/or provide access to, are critical elements of this infrastructure. In support of their mission to advance scholarship and research, these same libraries have been at the forefront of the technological revolution that has made this robust and evolving information infrastructure possible.

One of the most exciting and unanticipated results of the NSFNET has been the explosive growth of the network as a communications link. The enhanced connectivity permits scholars and researchers to communicate in new and different ways and stimulates innovation. Approximately one-quarter of the use of NSFNET is for E-mail, one-quarter for file exchange, 20% for interactive applications, and 30% for associated services. It is this latter category that is growing at an extraordinary rate and includes new and innovative library uses of networks. This growth rate demonstrates the value that researchers place on access to library and information resources in support of education and research. The following examples demonstrate the types of activities underway in academic and research libraries that utilize networks.

In the past year, the number of library online catalogs available on the Internet has jumped from thirty to over 160, including those in Canada, Australia, Germany, Mexico, New Zealand, Israel, and the United Kingdom. A single point of access to 100 online public access catalogs is possible today through a midwestern university. Access to resources identified in online public access catalogs are of increasing importance to researchers as they can access a greatly expanded array of information resources and in a more timely and efficient fashion. Needed information can be located at another institution, and depending upon the nature and format of the information, downloaded directly, and/or requested via interlibrary loan. Over time, this practice will likely change to the researcher obtaining the information directly online versus "ordering the information online." Typical use of an online catalog at a major research institution is that of LIAS at the Pennsylvania State University Library – there are approximately 33,000 searches each day of the LIAS system.

The National Agricultural Library, NAL, is supporting a project with the North Carolina State University Libraries to provide Internet-based document delivery for library materials. Scanned images of documents generate machine readable texts which are transmitted via the NSFNET/Internet to libraries, researchers work stations, and agricultural research extension offices. Images of documents can be delivered directly to the researchers computer, placed on diskette, or printed. This program will be extended to the entire land-grant community of over 100 institutions as well as to other federal agencies and to the international agricultural research community.

Another example of new library services that are possible with the use of the information technologies and networks, that meet a growing demand in the research community, and represent a network growth area are the licensing of commercial journal databases by libraries. Four of the last five years of the National Library of Medicine's MEDLINE database is accessible to the University of California community and there are approximately 50,000 searches of the system each week. There are numerous benefits to researchers and libraries including enhanced access to journal literature, there are lower costs to the library than from use of commercial systems, and the lower costs encourages greater use of the files by researchers thus promoting innovation. As other research libraries mount files, similar use patterns have occurred.

Although Internet access to proprietary files is not permitted, there are other services available such as UNCOVER that are more widely accessible. UNCOVER is a database with the tables of contents for approximately 10,000 multi-disciplinary journals developed by the Colorado Alliance of Research Libraries. The increasing demand for UNCOVER demonstrates the need for such services in the academic community and one that is available at a low cost for those institutions unable to locally mount proprietary files.

One area of networked services forecast to present new opportunities for dissemination and exchange of information in the scholarly and research communities and where a significant amount of experimentation and "rethinking" is anticipated, is in electronic publishing. Publishing electronically is in its infancy. Today, there are ten refereed journals on the Internet and it is anticipated that there will be many times this number in a short while. These journals, available via the Internet, range from *Postmodern Culture*, (North Carolina State University) to *New Horizons in Adult Education*, (Syracuse University) to *PSYCOLOQUY*, (American Psychological Association and Princeton University).

The nature and format of the electronic journal is evolving. To some, the electronic journal is a substitute to the "printed" journal. There are an increasing number of "paper-replicating electronic journals" and the growing number of titles on CD-ROM and the rapid rate of acceptance of this format, is a testament to the value of the electronic format. It is anticipated that many of the paper publishers will offer an electronic version of their journals via intermediaries such as DIALOG and CARL as the use of and capabilities of networks expand. This model also presents new dissemination choices to government agencies. The National Agricultural Library has begun to negotiate agreements with scholarly societies for the optical scanning of agricultural titles and information.

Another view of the electronic journal is one more of process, than product. Information or an idea is disseminated on the network for open critique, comment, dialog, and exchange. In this instance, publishing is an ongoing, interactive, non-static function, and one that encourages creativity, connectivity, and interactivity. Researchers experimenting in this camp are referred to as "skywriters" or "trailblazers." In fact, publishing in this arena takes on a new meaning due to the network's capabilities. The use of multi-media including sound, text, and graphics, the significantly expanded collaborative nature of the scholarly exchange not possible with a printed scholarly publication, and finally, the potential for a continuously changing information source, distinguishes this electronic journal from its counterpart, the paper-replicating electronic journal. An online publishing program on the Genome Project at the Welch Library at Johns Hopkins University is an example of this type of electronic publishing. Text is mounted on a database, accessed by geneticists, students, and critics who respond directly via electronic mail to the author. In this case, a computerized textbook is the end result but one which constantly changes to reflect new advances in the field. Funding from the National Library of Medicine has supported this project.

A final area where electronic publishing activities are underway is in the academic publishing community. Two examples of activities include efforts in the high energy physics and mathematics communities. A preprint database in high energy physics has been maintained for fifteen years by a university research facility with approximately 200 preprints added each week to the database of over 200,000 article citations. Instant Math Preprints (IMP), a new initiative that will maintain a searchable database of abstracts, will permit electronic file transfer of the full text of preprints. The project will be accessible via ten universities and "e-math," the American Mathematical Society's electronic service. The value to the research community of timely and effective exchange of research results will be enormous.

There are two predominant reasons that pilot projects and experiments such as these have been possible, have flourished, and been successful. First, a high value has been placed and a significant investment has been made in carefully constructed cooperative programs in the library community to advance research through the sharing of resources. The creation and support of bibliographic utilities such as the Research Libraries Information Network (RLIN) and the Online Computer Library Center (OCLC) has resulted in access by scholars to enormous databases of bibliographic records and information. Cooperative programs have been supported and encouraged by federal programs such as the Library Services and Construction Act of 1964 and the Higher Education Act of 1965. The Higher Education Act and in particular Title II-C and Title II-D programs have emphasized the sharing of resources between all types of libraries and users, and provided needed funds for support of technological innovations and developments. These programs have also promoted equality of access to information, ensuring that those collections housed in major research institutions, be broadly accessible.

The second reason that libraries have succeeded in advancing the exchange of information resources is the effective use of technologies to promote access. Most, if not all of these cooperative programs, are dependent upon networks in part, as the means to identify and share information resources. What will be required as more resources become available through the Internet will be the development of network directories. These directories will assist users in learning of what resources are available and how to access them. Provision of these electronic resources and the development of the ensuing access tools such as directories are already presenting many challenges to library and information science professionals and will require continuing attention if the NREN is to succeed.

As a consequence, the needed infrastructure to connect a diversity of users to a wide array of information resources is in place today. Networks interconnecting information resources and users throughout all parts of the United States and internationally, have been operational and effective for a number of years. A key factor that will permit the NREN to be a success is that much of the infrastructure is already in place. There are networks that interconnect academic institutions -- public and private, industrial users, and state consortiums, that include library networks and that do not distinguish between rural and urban, academic and K-12. The NREN vision must continue to encourage and demand enhanced interconnectivity between all users and all types of institutions.

As Congress considers how to best design the NREN to meet the needs of the research and academic communities, it will be important more than ever to include the goals and objectives of ongoing programs. In a time when there are 1,000 books published internationally each day, 9,600 different journals are published annually in the United States, the total of all printed knowledge is doubling every eight years, electronic information is just beginning to be exploited, and financial and funding resources are shrinking, it is critical that the research and education communities with continued federal support, strive for increased connectivity between all types of libraries and users. This connectivity will result in improved productivity and a strengthening of U.S. position in the international marketplace.

H.R. 656 should provide the necessary framework to achieve this enhanced connectivity. H.R. 656 should build upon existing programs and identify new means to permit information resources to be broadly available to the education and research communities. Ensuring connectivity through multiple types of libraries, throughout the United States, is a critical component to several existing statutes and should be included in NREN legislation. By so doing, the legislation would leverage existing federal, state, and local programs.

As libraries and users alike employ information technologies to access information resources, new opportunities and applications will develop that exploit the wealth of information and knowledge available in research libraries. Network applications today primarily focus on the provision of access to resources such as books, journals, and online files. Electronic publishing ventures are just beginning. In the years ahead, scholars and researchers will be able to access and use these research materials and collections generally unaccessible but of extreme research value including photographs, satellite data, archival data, videos and movies, sound recordings, slides of paintings and other artifacts, and more. Access to and manipulation of these information resources advances scholarship and research, and scholars will expect a network with the capacity and capabilities to achieve effective access. Clearly, to be successful, effective, and of use to the academic and research communities, the NREN must be designed to nurture and accommodate both the current as well as future yet unknown uses of these valuable information resources.

WASHINGTON OFFICE

AMERICAN LIBRARY ASSOCIATION

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March 12, 1991

The Honorable Rick Boucher
Chair, Subcommittee on Science
Committee on Science, Space, and Technology
U. S. House of Representatives
2319 Rayburn Building
Washington, D. C. 20515

Dear Mr. Boucher:

Enclosed is a statement of the American Library Association for the hearing record of March 7, 1991, on HR 656, the High-Performance Computing Act of 1991.

Sincerely,

/s/
Eileen D. Cooke
Director
ALA Washington Office

EDC:tj

Enclosure

cc: [redacted]

EXECUTIVE OFFICES: 50 EAST HURON STREET, CHICAGO, ILLINOIS 60611 • (312) 944-6780

Statement
# of the
American Library Association
to the
Subcommittee on Science and the Subcommittee on Technology and Competitiveness House Committee on Science, Space, and Technology

for the hearing record of March 7, 1991

on

HR 656, The High-Performance Computing Act of 1991

The National Research and Education Network, which HR 656 would create, could revolutionize the conduct of research, education, and information transfer. As part of the infrastructure supporting education and research, libraries are already stakeholders in the evolution to a networked society. For this reason, the American Library Association, a nonprofit educational organization of more than 51,000 librarians, educators, information scientists, and library trustees and friends of libraries, endorsed in January 1990 and again in January 1991 the concept of a National Research and Education Network.

ALA's latest resolution, a copy of which is attached, identified elements which should be incorporated in legislation to create the NREN, a high-capacity electronic highway of interconnected networks linking business, industry, government, and the education and library communities. ALA also joined with 19 other education, library, and computing organizations and associations in a Partnership for the National Research and Education Network. On January 25, 1991, the Partnership organizations recommended a policy framework for the NREN which also identified elements to be incorporated in NREN legislation.

Within that framework, ALA recommends the following additions to the pending NREN legislation to facilitate the provision of the information resources users will expect on the network, to provide appropriate and widely dispersed points of user access, and to leverage the federal investment.

NREN authorizing legislation should provide for:

A. Recognition of education in its broadest sense as a reason for development of the NREN;

B. Eligibility of all types of libraries to link to the NREN as resource providers and as access points for users; and

C. A voice for involved constituencies, including libraries, in development of network policy and technical standards.

NREN legislation should authorize support for:

A. **High-capacity network connections with all 50 states;**

B. **A percentage of network development funds allocated for education and training; and**

C. Direct connections to the NREN for at least 200 key libraries and library organizations and dial-up access for multitype libraries within each state to those key libraries. Prime candidates (some of which are already connected to the Internet) for direct connection to the NREN include:

- The three national libraries (Library of Congress, National Agricultural Library, National Library of Medicine) and other federal agency libraries and information centers;
- Fifty-one regional depository libraries (generally one per state) which have a responsibility to provide free public access to all publications (including in electronic formats) of U.S. government agencies;
- Fifty-one state library agencies (or their designated resource libraries or library networks) which have responsibility for statewide library development and which administer federal funds;
- Libraries in geographic areas which have a scarcity of NREN connections;
- Libraries with specialized or unique resources of national or international significance; and
- Library networks and bibliographic utilities which act on behalf of libraries.

The National Science Foundation, through its various programs, including science education, should provide for:

A. The inclusion of libraries both within and outside of higher education and elementary and secondary education as part of the research and education support structure;

B. Education and training in network use at all levels of education; and

C. Experimentation and demonstrations in network applications.

ALA enthusiastically supports development of an NREN with strong library involvement for several reasons.

1. **The NREN has the potential to revolutionize the conduct of research, education, and information transfer.** As basic literacy becomes more of a problem in the United States, the skills needed to be truly literate grow more sophisticated. ALA calls this higher set of skills "information literacy"—knowing how to learn, knowing how to find and use information, knowing how knowledge is organized. Libraries play a role in developing these skills, beginning with encouraging preschool children to read.

Libraries as community institutions and as part of educational institutions introduce users to technology. Many preschoolers and their grandparents have used a personal computer for the first time at a public library. Libraries are using technology, not only to organize their in-house collections, but to share knowledge of those collections with users of other libraries, and to provide users with access to other library resources, distant databases, and actual documents. Libraries have begun a historic shift from providing access primarily to the books on the shelves to providing access to the needed information wherever it may be located. The NREN is the vehicle librarians need to accelerate this trend.

In Michigan, a pilot program called M-Link has made librarians at a group of community libraries full, mainstream information providers. Since 1988, M-Link has enabled libraries in Alpena, Bay County, Hancock, Battle Creek, Farmington, Grand Rapids, and Lapeer to have access to the extensive resources of the University of Michigan Library via the state's MERIT network. The varied requests of dentists, bankers, city managers, small business people, community arts organizations, and a range of other users are transmitted to the University's librarians via telephone, fax, or computer and modem. Information can be faxed quickly to the local libraries from the University. Access to a fully developed NREN would increase by several magnitudes both the amount and types of information available and the efficiency of such library interconnections. Eventually, the NREN could stimulate the type of network that would be available to all these people directly.

School libraries also need electronic access to distant resources for students and teachers. In information-age schools linked to a fully developed NREN, teachers would work consistently with librarians, media resource people, and instructional designers to provide interactive student learning projects. Use of multiple sources of information helps students develop the critical thinking skills needed by employers and needed to function in a democratic society. This vision of an information-age school builds on today's groundwork. For instance, the New York State Library is providing dial-up access for school systems to link the resources of the state library (a major research resource) and more than 50 public, reference, and research library systems across the state. The schools had a demonstrated need for improved access for research and other difficult-to-locate materials for students, faculty, and administrators.

2. **Current Internet users want library-like services, and libraries have responded with everything from online catalogs to electronic journals.** As universities and colleges became connected to the Internet, the campus library's online catalog was one of the first information resources faculty and students demanded to have available over the same network. Some 200 library online catalogs are already accessible through the Internet. Academic library users increasingly need full text databases and multimedia and personalized information resources in an environment in which the meter is not ticking by the minute logged, the citation downloaded, or the statistic retrieved. A telecommunications vehicle such as the NREN can help equalize the availability of research resources for scholars in all types, sizes, and locations of higher education institutions.

Libraries will be looked to for many of the information resources expected to be made available over the network, and librarians have much to contribute to the daunting task of organizing the increasing volumes of electronic information. The Colorado Alliance of Research Libraries, a consortium of multitype libraries, not only lists what books are available in member libraries, but its CARL/Uncover database includes tables of contents from thousands of journals in these libraries. Libraries are also pioneering in the development of electronic journals. Of the ten scholarly refereed electronic journals now in operation or in the planning stages, several are sponsored by university libraries or library organizations.

3. **Libraries provide access points for users without an institutional base.** Many industrial and independent researchers do not have an institutional connection to the Internet. All such researchers and scholars are legitimate users of at least one public library. The NREN legislation as introduced does not reflect current use of the networks, much less the full potential for support of research and education. Because access to Internet resources is necessary to this goal, many libraries outside academe without access to academic networks have developed creative, if sometimes awkward, ways to fill the gap. A number of high schools have guest accounts at universities, but only a few have managed to get direct connections. CARL, the Colorado Alliance of Research Libraries, reaches library users regardless of the type of library they are using or their point of access. The development of community computer systems such as the Cleveland Free-net is another example of providing network access to a larger community of library users. Several Cleveland area public, academic, and special libraries are information providers on the Free-net as well.

Most of the companies in California high-technology centers either began as or still have fewer than 50 employees. For these companies, there is no major research facility or corporate library. The local public libraries provide strong support as research resources for such companies. The California State Library has encouraged and supported such development, for example, through grants to projects like the Silicon Valley Information Center in the San Jose Public Library. Library access to the NREN would improve libraries' ability to serve the needs of small business.

Support of research and education needs in rural areas could also be aided through library access to the NREN. Even without such access, libraries are moving to provide information electronically throughout their states, often through state networks. An example is the North Carolina Information Network. NCIN, through an agreement between the State Library and the University of North Carolina's Educational Computing Service, provides information access to almost 400 libraries in every part of the state—from university and corporate libraries in the Research Triangle Park, to rural mountain and coastal public libraries, to military base libraries. Using federal Library Services and Construction Act funds, the State Library provides the local equipment needed at the packet nodes to permit access to the system (called LINCNET) to these local libraries.

The information needs of rural people and communities are just as sophisticated and important as the needs of the people in urban areas. Because the North Carolina network is available in rural libraries, small businesses in these communities have access for the first time to a state database of all contracts for goods, services, and construction being put out for bid by the state—just one example of network contribution to economic development. The key to the network's growing success is the installation of basic computer and telecommunications hardware in the libraries, access to higher speed data telecommunications, and the database searching skills of the librarians.

4. **With libraries and their networks, the support structure to make good use of the NREN already exists.** Librarians have been involved in using computers and telecommunications to solve information problems since the 1960s when the library community automated variable-length and complex records—a task which was not being done by the computer field at the time. Librarians pioneered in the development of standards so that thousands of

libraries could all use the same bibliographic databases, unlike e-mail systems today which each require a different mode of address. The library profession has a strong public service orientation and a cooperative spirit; its codes of behavior fit well with that of the academic research community.

Libraries have organized networks to share resources, pool purchasing power, and make the most efficient use of telecommunications capacity and technical expertise. Upgrading of technological equipment and technological retraining are recognized library requirements, although the resources to follow through are often inadequate. The retraining extends to library users as well. Librarians are familiar with the phenomenon of the home computer or VCR purchaser who can word process or play a tape, but is all thumbs when it comes to higher functions not used every day. Computer systems, networks, and databases can seem formidable to the novice and are often not user-friendly. Expert help at the library is essential for many users.

5. **NREN development should build on existing federal investments in the sharing of library and information resources and the dissemination of government information.** The Internet/NREN networks are in some cases not technically compatible with current library networking arrangements. However, the government or university database or individual expert most appropriate to an inquiry may well be available only via the Internet/NREN. Access to specific information resources and the potential linkage to scarce human resources is one reason why most librarians are likely to need at least some access to the NREN.

As the Internet/NREN is used by various federal agencies, it becomes a logical vehicle for the dissemination of federal government databases. The Government Printing Office, through its Depository Library Program, has begun providing access to government information in electronic formats, including online databases. A unified government information infrastructure accessible through depository libraries would enable all sectors of society to use effectively the extensive data that is collected and disseminated by the federal government. Disseminating time-sensitive documents electronically would allow all citizens, small businesses, and nonprofit groups to have real-time access to government information through an existing organized system of depository libraries. The 51 regional libraries (generally one in each state, many of which are university and other libraries already connected to the Internet) could provide the original nodes for such a system. Together with major libraries capable of providing such support, these libraries could provide access for smaller libraries and selective depositories within their states or regions through dial-up facilities or local area networks.

The library community has been assisted and encouraged in its networking efforts by the federal government beginning in the 1960s, and more recently by state support also, in ways that track well with the NREN model. The federal government spends in the neighborhood of $200 million per year on programs which promote and support interlibrary cooperation and resource sharing and library applications of new technology. These programs range from the Library Services and Construction Act, the Higher Education Act title II, the Depository Library Program, the library postal rate, and the Medical Library Assistance Act to programs of the three national libraries—the Library of Congress, the National Agricultural Library, and the National Library of Medicine.

If academic libraries continue their migration to the Internet/NREN as the network of choice both on campus and for communication with other academic institutions, it will not be long before academic libraries and public libraries find themselves unable to talk to one another electronically. This result will be totally at odds with the goals of every major legislative vehicle through which the federal government assists libraries. In addition, it makes no sense, given the intimate connection of public libraries to the support structure for research and education. While public libraries have long been recognized as engines of lifelong learning, the connection is much more direct in many cases, ranging from the magnificent research resources of a New York Public Library to the strong support for distance learning provided by many public libraries in Western states.

Interlibrary loan and reference referral patterns also show that every kind of library supports every other's mission. The academic, public, school, state, national, and specialized libraries of the nation constitute a loose but highly interconnected system. A network which supports research and education, or even research alone, cannot accomplish the job without including this multitype system of libraries in planning, policy formulation, and implementation.

6. **The NREN's higher speeds will enable the sharing of full text and nontextual library and archival resources.** Libraries will increasingly need the higher capacity of the NREN to exploit fully library special collections and archives. The high data rates available over the fully developed NREN will make possible the transmission of images of journal articles, patents, sound and video clips, photos, artwork, manuscripts, large files from satellite data collection archives, engineering and architectural design, and medical image databases. Work has already begun at the national libraries and elsewhere; examples include the Library of Congress American Memory project and the National Agricultural Library text digitizing project.

7. **Libraries provide a useful laboratory for exploration of what services and what user interfaces might stimulate a mass marketplace.** One purpose of the NREN bills since the beginning has been to promote eventual privatization of the network. Libraries have already demonstrated the feasibility and marketability of databases in the CD-ROM format. Libraries also convinced proprietors and distributors to accommodate the mounting on local campus systems of heavily used databases. Libraries can serve as middle- to low-end network use test beds in their role as intermediaries between the public and its information requirements.

8. **Public, school, and college libraries are appropriate institutions to bridge the growing gap between the information poor and the information rich.** While we pursue information literacy for all the population, we can make realistic progress through appropriate public service institutions such as libraries. However, while an increase in commercial services would be welcome, any transition to privatization should not come at the expense of low-cost communications for education and libraries. Ongoing efforts such as federal library and education legislation, preferential postal rates for educational and library use, and federal and state supported library and education networks provide ample precedent for continued congressional attention to open and inexpensive access.

In conclusion, the NREN legislation would be strengthened in reaching the potential of the network, in ALA's view, with the addition of the elements we have enumerated above. Our recommendations represent recognition of the substantial investment libraries have already made in the Internet and in the provision of resources available over it, authorization of modest and affordable near-term steps to build on that base for library involvement in the NREN, and establishment of a framework for compatible efforts through other federal legislation, and state and local library efforts.

ATTACHMENT

WASHINGTON OFFICE
AMERICAN LIBRARY ASSOCIATION
110 MARYLAND AVENUE N.E. • WASHINGTON D.C. 20002 • (202) 547-4440

RESOLUTION ON A NATIONAL RESEARCH AND EDUCATION NETWORK

WHEREAS, The American Library Association endorsed the concept of a National Research and Education Network in a Resolution passed by its Council (1989-90 CD #54) on January 10, 1990; and

WHEREAS, Legislation to authorize the development of a National Research and Education Network has not yet been enacted; and

WHEREAS, High-capacity electronic communications is increasingly vital to research, innovation, education, and information literacy; and

WHEREAS, Development of a National Research and Education Network is a significant infrastructure investment requiring a partnership of federal, state, local, institutional, and private-sector efforts; and

WHEREAS, Libraries linked to the National Research and Education Network would spread its benefit more broadly, enhance the resources to be made available over it, and increase access to those resources; now, therefore, be it

RESOLVED, That the American Library Association reaffirm its support of a National Research and Education Network, and recommend incorporation of the following elements in NREN legislation:

- Recognition of education in its broadest sense as a reason for development of the NREN;
- Eligibility of all types of libraries to link to the NREN as resource providers and as access points for users;
- A voice for involved constituencies, including libraries, in development of network policy and technical standards;
- High-capacity network connections with all 50 states and territories;
- Federal matching and other forms of assistance (including through other federal programs) to state and local education and library agencies, institutions, and organizations.

Adopted by the Council of the
American Library Association
Chicago, Illinois
January 16, 1991
(Council Document #40)

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ADAPSO
the computer software and services industry association

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March 19, 1991

Hon. Tim Valentine
Chairman
Subcommittee on Technology and Competitiveness
House Committee on Science, Space, and Technology
RHOB B374
Washington, DC 20515

Dear Mr. Chairman:

ADAPSO, The Computer Software and Services Industry Association, offers the following comments for inclusion in the record of the March 7 joint hearing with the Subcommittee on Science on H.R. 656, the National High Performance Computing Act. As an active member of the High Performance Computing Coalition, ADAPSO strongly supported legislation in the last Congress and continues to do so now. We are heartened that you have held an early hearing on this important legislation and look forward to passage this year.

ADAPSO continues to prefer legislation, like the House bill, which lodges policy and management leadership in the Office of Science and Technology Policy and the National Science Foundation, rather than in any operating agency. The great virtue of this initiative, relative to other "big science" proposals, is that upgraded computing will benefit agency missions, scientific disciplines, and industrial applications across the board. Computing can truly be called a neutral enabling technology, and the federal program should be carried out in that spirit.

While ADAPSO has applauded the Administration's budget request for high performance computing, and called for full funding, we continue to believe in the usefulness of broad authorizing legislation, which is after all the standard way to manage large funding programs. In particular, legislation can provide direction in commercialization policy, not traditionally an area of NSF responsibility. Moreover, the bill can set a moderate direction in the difficult area of rights in technical data, including software, still under development by the General Services Administration.

We agreed with much of the testimony you received. However, one statement in particular calls for a response. Without support, the Bell Atlantic statement refers to the 1982 AT&T Modified Final Judgment (MFJ) as a barrier to its involvement in high performance computing services. The fundamental job for local exchange carriers, such as those owned and operated by Regional Holding Companies, is to provide highly reliable, reasonably priced, ubiquitous data transport services. The Bell companies generally do this job well. Curiously missing from the statement, however, is any reference to the Bells' welcome development of a projected new 45-megabit offering, Switched Multi-megabit Data Service (SMDS). Indeed, Mr. Raymond Albers of Bell Atlantic told the February 14, 1991 Office of Technology Assessment workshop on a privatized National Research and Educational Network (NREN), "...[W]e are highly encouraged by results of current trials and expressions of user interest [in SMDS]" (enclosed statement, p. 5). At the same workshop, Mr. Larry Kappel of U S WEST offered considerable detail on SMDS, stating that it would be offered by some Bell companies next year. Clearly, current antitrust policy has in no way impeded the Bell companies from developing plans for improved data transport.

The comparison to waivers which the Bell companies received from Judge Greene for participation in FTS 2000 is only partially apposite. With FTS 2000, the Federal Government is the sole customer. As the largest entity in the U.S. economy, the Government scarcely needs protection against private monopoly power. However, the projected National Research and Educational Network (NREN) would serve numerous users beyond the Government. These private users will continue to need antitrust protection under the Modified Final Judgment against abuse of power by monopoly telecommunications carriers.

This bill is not the place to debate telecommunications policy issues now properly before the Energy and Commerce Committee. The Subcommittees have been presented a position which, to date, has not prevailed either in the Courts or in Congress. For the Subcommittees to enter into this controversial policy area would simply invite subsequent referral to the Energy and Commerce Committee, producing an uncertain future for H.R.656.

Again, Mr. Chairman, ADAPSO thanks you for your early and favorable attention to this legislation. For any questions or further assistance, please contact David Peyton, 703/284-5352.

Yours truly,

Sheldon Bentley
Functional Vice President
Government Relations

cc: Rep. Boucher

Enclosures (2)

THE PRIVATIZED NREN

MARKET PLACE ISSUES

OTA WORKSHOP

FEBRUAY 14, 1991

VIEWS OF RAYMOND F. ALBERS - BELL ATLANTIC

The word network typically has vastly different connotations to a telephone carrier and a computer network user. The former tends to think of the collection of everything necessary to establish and maintain highly available, highly reliable easy to use connection oriented communication paths among any pair of entities from among the literally millions of entities connected to the network. "Entities" here means anything from simple voice telephone instruments from fairly sophisticated and relatively high speed computer communications devices such as modems.

A computer user on the other hand tends to think of a network as the collection of user services or applications available from local and remote computing resources. To the computer, or the computer user, the network looks more like a service or an application and the underlying structure is visible only to those who are interested in it technically, such as those who have to figure out how to lash it together.

Almost every "telephone" person I know readily admits that telcos have not been architects, designers or providers of computer networks in any meaningful sense. Telcos and Internet users are largely invisible to each other. The Internet users are largely unaware of the existence of the carriers in the applications they are using, except to the extent that they might have used a dial-up modem to access a local host, or they may be dimly aware that there are some kind of "phone lines" connecting the various sites that they know about. Similarly, the telco's awareness is usually limited to knowing that there is some kind of computing equipment connected to the private line services provided to various government and commercial sites, and a dim realization that there are probably, somewhere, users associated with those computer systems.

Actually, the state of knowledge is not as woefully bleak as I've described it, and in any case the foregoing is more a description of what has been than what we are striving for. Actually, many of us do understand a little about computer communications and networking and are very much involved in long range technical planning, research, and standards activities to support it. Most of our near term action in these areas has been in writing software for and operating some fairly large computer networks of our own, which provide operations support, billing, etc. for the telecom network. In fact, it can truly be said that few corporations have as many computers, particularly networked computers, as the telephone companies. Without even trying to count the computers, reflect for a moment that Bell Atlantic alone has to manage something like 18 million telephone access lines, about a thousand central office switching systems, over a half million miles of optical fiber (and the electronic systems connected to it), several times that amount of copper cables, hundreds of unmanned equipment locations, and much more. And, every day there is "churn" activity on thousands of those telephone lines: people moving in, moving out, adding services, disconnecting services, and on and on. Obviously, you just don't run an operation that big without lots of computers connected to each other. And I haven't even mentioned the care and feeding of the 80 thousand employees, the motor vehicles, the buildings, the furniture etc. Somewhat to our chagrin, the telecommunications services provided to all of our own computers, however, have largely been the same kinds of "dumb" circuit connections that we are providing to Internet users.

This is all changing, albeit not as fast as many of us would like. There are several factors to consider. First, the infrastructure is getting better suited to higher speed data communications. Noise sensitive analog transmission systems have given way to digital. Electro-mechanical switching offices, whose relays produced such large spikes of impulse noise, have been replaced with stored program controlled analog and digital central offices. It is true that modems have gotten faster and cheaper mostly due to advances in microcircuits and other electronics, one cannot ignore the enabling improvements that have been made in the telecom infrastructure. I seriously doubt that today's 2400 baud modems would provide acceptable performance if they were transported back in time and connected to the telephone networks of the 60's and 70's. The advances in the infrastructure - particularly the significant penetration of optical fiber and digital transmission systems - will increasingly make it possible to implement higher speed network services. Not only can the bit rates be faster but improvements in noise and error performance enable more streamlined link and network layer protocols (e.g. edge-to-edge vs. link-by-link error checking) to improve throughput.

Another factor that is driving change, and this is perhaps the most important factor, is that our (the telcos') perception of the role we want to or should play is changing. We are looking for ways to provide public switched data services just as we provide public switched voice services. We believe that as we gain datacom experience and as suitable equipment becomes available to us we will do for switched data services what we are doing so superbly for switched voice services. Managing service establishment, routing, traffic engineering, address management and other functions go into a ubiquitously available, highly reliable high quality reasonably network will be extended to switched data services as well as voice. Admittedly, our initial ventures into this area, our X.25 packet networks, have not been wildly successful, but I get the impression that *nobody's* X.25

network is wildly successful. How well we do with our higher speed connectionless SMDS networks remains, of course, to be seen, although we are highly encouraged by results of current trials and expressions of user interest.

Another important infrastructure enabler is ISDN, which is about to emerge from its island stage into a true national network capability. The interoperability agreements recently reached between the RBOCs and the major switching system suppliers, and the interconnection of RBOC and interexchange carriers' common channel signaling networks, which has also begun, is making national ISDN a reality. ISDN will mean much more than faster dial-up access for individual users. For example, Bell Atlantic is now testing a product that will take advantage of the very rapid call setup available with ISDN, aggregate B channels as required for higher bandwidth on a single logical connection and achieve LAN-like performance with applications transparency over the public switched network. The potential for LAN to LAN or server to server file transfers using bandwidth only as and when needed, is huge. Routing concerns and address management are greatly alleviated.

I believe the RBOCs and interexchange carriers should have a significant role in providing services through layer 3 of the NREN, providing the address space management, switching and routing among users and sites. Planning and implementation of NREN should take full advantage of the carriers' emerging network capabilities in these areas.

The picture for higher layer services is less clear. We are already providing storage services, menus and similar functions in our gateway services but these issues are still clouded. I would welcome discussion of what types of services users would like us to provide!

US WEST Perspective on NREN Marketplace Issues, January 18, 1991

NREN/Internet Issue	Planned SMDS Capability
New applications are demanding multimegabit bandwidth	Fiber already deployed; 1.5, 45, 155 Mbps
Dynamic load variations and unpredictable congestion	High-capacity, diverse routing, LAN-like connectionless network service
Inter-vendor incompatibilities	RFC for IP over SMDS, standardized 802.6 Interface, E.164 addressing, SNMP/CMIP Network Management, T1, DS3, SONET
Congestion and flow control	Credit Manager enforces limits of offered traffic
Accounting and cost allocation	Usage-measurement, tariffs
Security	Closed, private virtual networks
IP addressing not congruent with public network evolution	Internationally compatible ISDN addressing

US WEST Perspective on NREN Marketplace Issues, January 18, 1991

U S WEST Perspective on Marketplace Issues
relative to
Privatization of the NREN

Position Paper to:
The Office of Technology Assessment
Congress of the United States

For:
OTA Workshop:
"The Privatized National Research and Education Network (NREN)"
February 14, 1991
Washington, D.C.

From:
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By:
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US WEST Perspective on NREN Marketplace Issues, January 18, 1991

Purpose

This paper presents U S WEST's response to OTA's request for an "essay [which] will depict that participant's understanding of his company's or organization's definition of its market niche and its assessment of the overall conditions of marketplace in which it finds itself operating". This has been requested to be provided by U S WEST as input to the OTA Workshop on The Privatized NREN. The information gained from this workshop will be used as input to the OTA's assessment of the NREN to be presented to Congress.

The OTA Workshop has been planned to help identify the full range of issues regarding the potential of a commercial TCP/IP Internet market. Participants include existing and potential service providers, as well as existing Internet administrators.

This paper is presented as a working paper only, and is not intended to represent a final US WEST position.

Background

The OTA is currently soliciting industry comments as input to their study focusing on the privatization of the National Research and Education Network (NREN). The NREN is under consideration by the U S Congress for funding this year in the form of Bill SB 1067 (revised) to be be resubmitted this year. The NREN is a proposed networking and computing infrastructure for research and education in the U.S. and is intended to upgrade the Internet, specifically the NSFNet, the current backbone network of the Internet.

The trends towards privatization of the Internet has raised many concerns by OTA as to what policy should be recommended in its study. Numerous technical, operational, political, funding, and regulatory issues exist in this area.

U S WEST's Market Position

U S WEST recognizes the trend that a large variety of corporations, government agencies, and academic organizations have rapidly increasing needs for high-speed data communications services requiring the capability to transmit information at multi-megabit rates.

This trend is also apparent in the Internet community. In this regard, U S WEST is taking a complementary position relative to TCP/IP network provisioning for the NREN and the Internet. U S WEST currently is not focusing on providing TCP/IP networking services, per se, but rather on deploying a common data switching infrastructure that can be applied to TCP/IP as well as a broad range of other protocols. For several years we have been planning this infrastructure and is based on cell-switching technology that allows for very-high speed (100's of megabits per second) digital switching. This data switching infrastructure is premised on international standards and interconnectivity among carriers.

U S WEST's long-range objective (which we understand is that of the other RBOCs and many other carriers) is the Broadband Integrated Services Digital Network (B-ISDN), based on common cell-switching for all communications traffic, including voice, data, and video. SMDS^{SM*}, a switched multimegabit data service, is the first cell-switched service which will eventually be carried over B-ISDN, and will be offered by certain RBOCs beginning next year. SMDS has been purposely designed so that the customer's embedded base of Local Area Networking investment is preserved because the service provides a virtual Local Area Network (LAN), spanning long distances. In fact, the SMDS service is based on the IEEE 802.6 LAN/MAN Standard.

In this way, the SMDS service allows users to extend over a wide area the efficiencies they now realize within their own local environments, without incurring costs for dedicated high-bandwidth private lines. As an indication of the support for SMDS in the Internet community, the Internet Engineering Task Force (IETF) has recently approved a standard RFC (request for comment) for IP over SMDS. This will enable standardized IP networking over SMDS. The attached Appendix, "Technical SMDS Discussion", presents details on technical advantages of SMDS to TCP/IP networking.

Bellcore and its Bell Client Companies decided to develop the SMDS communications service so that it can support a wide range of data communications protocols, and is intended to provide better price-performance than private lines for data applications. A major advantage of the SMDS service is that a consistent service will be preserved as the network is upgraded with new generations of technology, up to gigabits per second. In this way, it can meet today's high-speed data communications needs, as well as tomorrow's.

In the TCP/IP world, U S WEST sees itself primarily as a provider of underpinning communications services which are used to support TCP/IP networks. From our perspective, IP routers can be owned and operated by any TCP/IP network provider. Regardless of ownership, improved IP subnetworks can be built from the SMDS service, because routers will enjoy the benefits of higher speed public network facilities. Since SMDS serves to group routers on the same "LAN", the routers have a considerably simplified view of the IP subnetwork. Packet throughput can be significantly increased, because switching is moved from the router to the high-efficiency SMDS switching fabric. SMDS can provide better communications between routers, and therefore improve the overall performance and manageability of IP backbones, mid-level networks, and access networks.

What this means to the TCP/IP network provider, whether a backbone or mid-level network, is that intelligent communications services can be procured which can offload many transmission, switching, cost allocation, and management tasks. Since SMDS helps to offload these tasks, the TCP/IP network provider can concentrate more on the primary business of the administration of policy within the network provider's IP domain.

SMDS provides features which enable more efficient implementation of such policy within IP internetworks. These features include multicast, address screening, access classes, usage measurement, and network management systems. More detail is presented in the Attachment.

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[*] SMDS is a service mark of Bell Communications Research.

APPENDIX - Technical SMDS Discussion

Today, multi-megabit data networking is widely accepted in the form of LANs, offering powerful solutions to local communications needs. Yet this sophisticated networking in the local environment stands in dramatic contrast to current methods of inter-premise communications, which remain highly limited in bandwidth and/or connectivity. Recognizing that users are requiring the extension of flexible multi-megabit communications beyond their premises, U S WEST has directed the development of SMDS through Bellcore.

The primary goal of SMDS has been to be compatible with and enhance the value of the customer's embedded network base. This embedded base may consist of many different types of local-area and wide-area subnetworks. By virtue of providing a protocol-independent "subnetwork" as part of the customer's overall collection of subnetworks, SMDS can be easily incorporated into their existing configuration. Proven interworking techniques can be used, such as bridging (e.g. transparent LAN bridging) or routing (e.g. IP - Internetwork Protocol). SMDS can be viewed as a subnetwork having the functional advantages of a LAN, yet covering geographic areas typically served by a WAN. In this way, SMDS offers the capability required to fill the price/performance gap between LAN and WAN environments.

SMDS allows the LAN model to be extended over wide areas. It is a high-speed (1.5 Mbps, 45 Mbps, and 155 Mbps interface), connectionless (similar to IP and LANs), secure, universally addressable service providing flexible bandwidth communications providing the same service interface as LAN communications. It has purposely been designed to use the most cost-effective transmission facilities available - T1, DS3, and soon SONET. Moreover, the SMDS service was also designed to be robust, reliable, and managed by universal management systems.

Currently, IP routers must take the responsibility for forwarding packets from router to router within routing domains, whereas with SMDS, routers will be able to view all of the other domain's routers as being on the same "LAN", all reachable in one hop. In this way, extra bandwidth is available when needed, as traffic demands vary. Packet delays are significantly reduced, efficiency is increased, total costs are lower, and are easier to track.

In addition to IP packet routing, SMDS can serve as a delivery vehicle for LAN, FDDI, DECnet, SNA, XNS, and OSI traffic, thereby encompassing many potential revenue sources which will serve to improve economies of scale. This same phenomenon serves to drive the cost of private lines lower and lower, and is a primary reason SMDS was defined to have a high degree of transparency to higher layer protocols.

Since SMDS will use standards such as North American Digital Hierarchy transmission facilities (T1, DS3, SONET), universal addressing (CCITT E.164), IEEE LAN interfaces, SNMP/CMIP network management, and telephone network billing and operations systems, SMDS offers a catalyst for elegantly combining private datacomm environments (LANs, TCP/IP) with public telecommunications environments.

The following table lists some key NREN/Internet issues and shows how SMDS can help to alleviate those issues.

US WEST Perspective on NREN Marketplace Issues, January 18, 1991

Since the RBOCs are legally limited to intra-LATA connectivity, SMDS will be offered by and interconnected with interexchange and other local-exchange carriers. This has actually strengthened the potential for SMDS acceptance, because it has been nationally coordinated.

Significant interest has developed by the TCP/IP community relative to SMDS, because the SMDS service is so highly synergistic with IP and LAN protocols. Demonstrations of a national SMDS service were held at the INTEROP/90 Conference and Exhibition in October 1990 and was widely embraced by users, vendors, and network providers as a viable option for meeting growing TCP/IP data communications needs.

Currently, U S WEST plans to use SMDS internally and to deploy applications trials as a means of developing insights as to future applicability to external markets. SMDS support systems are the key to this successful service, and U S WEST has supported efforts through Bellcore to develop complete specifications for them.

U S WEST supports NREN, and endorses its goal of a being a national resource for education and research. Rather than aligning with specific TCP/IP network providers, U S WEST has considered itself in the business of being a provider that can supply economies across a maximum number of customer needs. In anticipation of these rapidly expanding needs, U S WEST has and will continue to invest in the long-range infrastructure that can meet the needs of a broad range of data communications, including TCP/IP.

It is apparent to U S WEST that TCP/IP growth will continue for many years, and so our objective is to leverage our experience in large public networks to the benefit of the TCP/IP world. Even though public policy issues may go on for years regarding the NREN and the Internet, U S WEST anticipates deploying the SMDS service with the confidence that it can enable high-speed IP internetworking for all TCP/IP network providers.

CONVEX COMPUTER CORPORATION
WRITTEN STATEMENT
Presented to
U.S. House of Representatives
House Science, Space and Technology
Subcommittee on Technology and Competitiveness
Subcommittee on Science

CONVEX supports H.R. 656, the High-Performance Computing Act of 1991, as we believe it will assist U.S. industry in maintaining leadership in computing technology. We strongly believe this legislation can positively contribute to one of the biggest threats facing the United States today: the loss of our international competitiveness in all technology related businesses. In addition, it will directly stimulate the supercomputing industry.

As Congressman George Brown has so aptly stated, Europe and Japan have targeted information technologies for particular attention, and unless decisive steps are taken to ensure our continued leadership, the U.S. could be surpassed in a technology field that we largely pioneered and which is vital to our economic future.

The real American competitiveness question involves making our nation's industries competitive. The use of supercomputers is mandatory to maintaining America's competitive edge in all of our key industries, such as aerospace, automotive, electronics, pharmaceuticals, petroleum, etc. -- not just in supercomputing manufacturing.

We believe the actions called for in H.R. 656 -- particularly the acceleration of the development of computer systems and subsystems, the stimulation of research on software technology, and the application of high-performance computing to "Grand Challenges" -- are not only appropriate goals, but vital to maintaining the U.S. lead in supercomputers and utilizing supercomputer technology in our high-tech industries and research.

Supercomputers are the fundamental building blocks that contribute to almost all disciplines across the broadest spectrum of science and technology. In the 1990's, the way America can stay competitive is literally to put supercomputing in the hands of the "masses." Supercomputers are to the modern technologist what the invention of the microscope was to biologists and the telescope was to astronomers. In fact, supercomputers enable scientists and engineers to solve problems for things that are too small, too large, too quick, too slow, or too dangerous to observe directly. This use in industry results in new products that are more innovative, safer, and get to market more quickly. Their use in research results in fundamental breakthroughs in science that change how we see the world. The supercomputer is the one common tool across all U.S. scientific and technological activities that, if put in the hands of engineers and scientists throughout the United States, can dramatically sharpen the competitive output of the United States.

Of course, Japanese industry and research institutions totally understand and believe these concepts. From our perspective, they have been the fastest nation to purchase CONVEX's latest technology. Until just recently, there were more of CONVEX's top-of-the-line supercomputers in Japan than in the United States. American researchers and engineers believe these concepts also, but access to supercomputer tools has been limited. H.R. 656 can be the catalyst to change this trend.

CONVEX's assessment of the competitive position of the high-performance computer industry in the U.S. relative to that of Japan is as follows:

The high-performance computer market is an international market in which Cray dominates the high-end of the market, and CONVEX dominates the mid-range market. The Japanese computer manufacturers, NEC, Fujitsu, and Hitachi, have high performance, fast hardware products. But while this is the case, U.S. high performance computer companies currently maintain the lead in supercomputing for the following reason: supercomputing is not about hardware, it's about solving complex problems. The U.S. supercomputer companies are ahead of foreign competition because we understand there are four aspects to supercomputing solutions:

- o Balanced, high-performance hardware: There is more to real performance than pure megaflops or gigaflops performance. Unfortunately, that's how performance is commonly measured but these definitions must be properly interpreted. There is much more to useful performance than peak speed, such as software performance, memory performance, and I/O performance. Users care only about the performance of their applications -- the problems they specifically solve with their machines -- and this type of performance is determined by dozens of attributes. In terms of speed, the Japanese have high peak performance, but that's only a part of the supercomputing solution.

- o Software technology -- Operating systems (UNIX^{TM}) and compilers: Maintaining the lead requires being proficient at several software standards. Companies such as CONVEX and Cray recognized the emergence of the UNIX standard long ago and designed their machines for UNIX -- now considered a requirement in supercomputing. Japanese systems have historically been based on IBM standards and only now are attempting to migrate to UNIX. Also superior compiler technology is critical to computing performance and productivity. American companies and research institutions lead in this areas, as well.

- Application specific software: Most of the supercomputers in use today, especially in industry, utilize third-party written software applications rather than custom-written software applications. The majority of that third-party software is developed by U.S. based organizations. CONVEX considers having both a broad array of application software available on its machines and having agreements/relationships with the software developers, as critical elements of its competitive strategy and success. American suppliers are leading in this crucial area.

- Service and support -- taking care of the customer: This is a critical component in supercomputing solutions. American companies' reputations in the area of service and support are superior. American suppliers utilize direct sales and support organizations in all major markets and, as such, are closer to the customer. Outside of Japan, Japanese manufacturers typically use distributors or OEMs for sales and customer support.

It would be naive to believe that U.S. companies will always be able to maintain the supercomputer lead for the reasons cited above without continual development and diligence in these areas. The Japanese can -- and will, in time -- develop these necessary strengths. Although CONVEX has been selling its supercomputers successfully to the Japanese for almost six years now, we also realize that when, or if, the Japanese companies decide that the price/performance market niche that CONVEX currently dominates is a viable and sizable market for Japan, the competitiveness threat posed by Japan can become very serious.

The biggest threats posed by the Japanese to American supercomputer companies are:

- The size of the big three Japanese companies is over $89 billion, which provides substantial financial staying power. This gives them the ability to mask the success or lack of success of their supercomputer products versus U.S. supercomputer companies, whose existence relies solely on the success of their supercomputers.

- Furthermore, they can afford to not be profitable in the supercomputer market segment for a very long period of time and can buy market share by excessive and unreasonable discounting, while public U.S. companies are forced to live by quarter to quarter reporting, which represents the results of a single technology focus.

- The big three Japanese computer companies also dominate the semiconductor industry, including advanced semiconductor research and development required to build supercomputers.

- The cost of capital differs substantially for U.S. versus Japanese companies.

In light of these factors, staying competitive in today's global supercomputer market will take a concerted effort by American companies, as well as cooperation and constructive stimulation by government. Certainly, the High-Performance Computing Act of 1991 will be a positive contribution in this direction.

Comments on the bill, H.R. 656

General Comments

CONVEX enthusiastically supports this legislation and commends it to you for your favorable consideration and swift passage in the House. We fully support the idea of a "National High-Performance Computing Program." There are several provisions of the bill on which I would like to comment and highlight.

The High-Performance Computing Advisory Panel

The federal government has played a prominent role in the American supercomputing success story and H.R. 656 again demonstrates this leadership. In several areas of the bill, cooperation between government and industry is called for to review progress made in implementing the plan and making necessary revisions. In particular, the bill calls for the establishment of a High-Performance Computing Advisory Panel consisting of representatives from industry and academia to assist with these tasks. I want to highlight this concept as being extremely important to achieving the objectives of the bill. The results of the expenditures for equipment and research called for by the bill must ultimately be the development of competitively superior commercial products. The strategic plan that is put into place by this bill should have this as a fundamental objective. Government is better qualified for some aspects of the task, and industry is better qualified for others. Partnership between the two will allow the plan to utilize the best capabilities of both. CONVEX has exposure to applications, research and product developments occurring all over the world, and in the broadest of scientific areas. We volunteer to help in whatever ways we can.

The National Research and Education Network (NREN)

CONVEX fully supports the bill's provision calling for the creation of a multi-gigabit-per-second National Research and Education Network (NREN). It is our perspective that in the past, too much emphasis was placed on providing limited access to too few centralized machines. Supercomputing must be made available to, and meet the needs of, a broad base of users through widely distributed supercomputer systems placed closer to the ultimate user. This would not supplant the centralized machines, but rather complement them.

I suggest that in establishing NREN, it should not only be envisioned as a multi-gigabit per second backbone network, connecting only a small number of very high[speed, centralized computer systems. Let's think of it as a distributed network of computing and telecommunications services, serving the widest possible number of scientists and engineers from government, industry and academia. The National Science Foundation's national supercomputer centers represent a case in point. The program has been a success, but we can learn from what those users are additionally asking for: supercomputing close to the user. Let's supplement and complement the national supercomputer centers with affordable, open, accessible supercomputing facilities, available in departments and dedicated to products across the nation. Let's put a broad range of supercomputers, distributed data bases, and other research and production facilities, in the very laps of those who need them to help maintain and regain America's preeminence in many disciplines.

Software

In the last ten years, only about 300 high-end supercomputers have been sold by U.S. companies to industry and to research institutions. From CONVEX alone, over 600 high-performance computing systems have been shipped in only five years. American industry needs distributed, affordable supercomputing power to remain competitive. These companies, large and small, are voting with their checkbooks for this means of providing supercomputing. They are using supercomputing in production environments, not just in their research laboratories. They need supercomputers to bring new and improved products to market faster. Supercomputers are a valued competitive weapon for all of these companies.

The full utility of supercomputers can only be reached through software. The sophisticated supercomputing user community desperately needs improved software development tools, computer-assisted software engineering (CASE) capabilities, and better algorithmic methods. With this improved state-of-the-art software, we can move forward with attacks on the Grand Challenges enumerated in the bill.

CONVEX wholeheartedly supports the software tasks and goals of the bill. Care should be taken to ensure that resources are not wasted by reinventing what may already exist in industry or somewhere in the world. Let's concentrate on improving software technology, but adhering to industry standards wherever possible, and avoiding proliferating proprietary solutions to software problems.

Basic Research and Education

CONVEX strongly supports the provisions of the bill in the areas of basic research and education. Only the largest and richest corporations can afford to have very much of their resources dedicated to basic research. Most of the industry, and I count CONVEX in this group, must use its limited research and development resources in the development and production of the next generations of our commercial products. So we need a fertile source of basic research if the supercomputer industry and the nation are to progress.

Again, this must be treated as a partnership. We must create effective, efficient, fast-acting technology transfer mechanisms so that our basic research can be fully utilized. We, therefore, recommend that the bill specifically call for the creation of a separate, responsible Technology Transfer Program Office to insure that basic research is translated into products to be used to further all of our goals.

In the area of education, the United States needs a great deal of assistance to help us remain competitive. The bill's provisions to educate and train additional undergraduate and graduate students in software engineering, computer science, and computational science and to provide researchers, educators, and students with access to high-performance computing are extremely worthwhile. However, the intent of the bill should be applied across the board in the supercomputing industry and should include mechanical engineers, packaging engineers, chemical engineers and others.

Summary

In summary, I recommend this bill to you. The amount of funding called for by this bill is indeed small when compared to the significant economic benefit the program will bring to U.S. industrial competitiveness. It is essential that the United States remain aggressive in the area of supercomputer technology. This bill will combine the resources of U.S. industry, government, and universities to meet the challenge of foreign competition.

United States General Accounting Office

GAO

Testimony

For Release
on Delivery
Expected at
9:30 a.m. EST
Thursday
March 7, 1991

Supercomputing in Industry

Statement for the record by
Jack L. Brock, Jr., Director
Government Information and Financial Management Issues
Information Management and Technology Division

Before the
Subcommittee on Technology and Competitiveness
Committee on Science, Space, and Technology
United States House of Representatives

Messrs. Chairman and Members of the Committee and Subcommittee:

I am pleased to submit this statement for the record, as part of the Committee's hearing on the proposed High Performance Computing Act of 1991. The information contained in this statement reflects the work that GAO has conducted to date on its review of how industries are using supercomputers to improve productivity, reduce costs, and develop new products. At your request, this work has focused on four specific industries--oil, aerospace, automobile, and pharmaceutical/chemical--and was limited to determining how these industries use supercomputers and to citing reported benefits.

We developed this material through an extensive review of published documents and through interviews with knowledgeable representatives within the selected industries. In some cases, our access to proprietary information was restricted. Since this statement for the record reports on work still in progress, it may not fully characterize industry use of supercomputers, or the full benefits likely to accrue from such use.

BACKGROUND

A supercomputer, by its most basic definition, is the most powerful computer available at a given time. While the term supercomputer does not refer to a particular design or type of computer, the basic design philosophy emphasizes vector or parallel processing,[1] aimed at achieving high levels of calculation very rapidly. Current supercomputers, ranging in cost from $1 million to $30 million, are capable of performing hundreds of millions or even billions of calculations each second. Computations requiring many hours or days on more conventional computers may be accomplished in a few minutes or seconds on a supercomputer.

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[1] Vector processing provides the capability of operating on arrays, or vectors, of information simultaneously. With parallel processing, multiple parts of a program are executed concurrently. Massively parallel supercomputers are currently defined as those having over 1,000 processors.

The unique computational power of supercomputers makes it possible to find solutions to critical scientific and engineering problems that cannot be dealt with satisfactorily by theoretical, analytical, or experimental means. Scientists and engineers in many fields--including aerospace, petroleum exploration, automobile design and testing, chemistry, materials science, and electronics--emphasize the value of supercomputers in solving complex problems. Much of this work centers around scientific visualization, a technique allowing researchers to plot masses of raw data in three dimensions to create visual images of objects or systems under study. This enables researchers to model abstract data, allowing them to "see" and thus comprehend more readily what the data reveal.

While still relatively limited in use, the number of supercomputers has risen dramatically over the last decade. In the early 1980s, most of the 20 to 30 supercomputers in existence were operated by government agencies for such purposes as weapons research and weather modeling. Today about 280 supercomputers[2] are in use worldwide. Government (including

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[2] This figure includes only high-end supercomputers such as those manufactured by Cray Research, Inc. Including International Business Machines (IBM) mainframes with vector facilities would about double this number.

defense-related industry) remains the largest user, although private industry has been the fastest growing user segment for the past few years and is projected to remain so.

The industries we are examining enjoy a reputation for using supercomputers to solve complex problems for which solutions might otherwise be unattainable. Additionally, they represent the largest group of supercomputer users. Over one-half of the 280 supercomputers in operation are being used for oil exploration; aerospace modeling, testing, and development; automotive testing and design; and chemical and pharmaceutical applications.

THE OIL INDUSTRY

The oil industry uses supercomputers to better determine the location of oil reservoirs and to maximize the recovery of oil from those reservoirs. Such applications have become increasingly important because of the low probability of discovering large oil fields in the continental United States. New oil fields are often small, hard to find, and located in harsh environments making exploration and production difficult. The oil industry uses two key supercomputer applications, seismic data processing and reservoir simulation, to aid in oil exploration and production. These applications have saved money and increased oil production.

Seismic data processing increases the probability of determining where oil reservoirs are located by analyzing large volumes of seismic data and producing two- and three-dimensional images of subsurface geology. Through the study of these images, geologists can better understand the characteristics of the area, and determine the probability of oil being present. More accurately locating oil reservoirs is important because the average cost of drilling a well is estimated at about $5.5 million and can reach as high as $50 million. Under the best of circumstances, most test wells do not result in enough oil to make drilling cost-effective. Thus, avoiding drilling one dry well can save millions of dollars. The industry representatives who agreed to share cost estimates with us said that supercomputer use in seismic data processing reduces the number of dry wells drilled by about 10 percent, at a savings of hundreds of millions of dollars over the last 5 years.

Reservoir simulation is used to increase the amount of oil that can be extracted from a reservoir. Petroleum reservoirs are accumulations of oil, water, and gas within the pores of rocks, located up to several miles beneath the earth's surface. Reservoir modeling predicts the flow of fluids in a reservoir so geologists can better determine how oil should be extracted. Atlantic Richfield and Company (ARCO) representatives estimate that reservoir simulation used for the oil field at Prudhoe Bay, Alaska--the largest in production in the United States--has resulted in increased oil production worth billions of dollars.

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[3] Seismic data are gathered by using sound-recording devices to measure the speed at which vibrations travel through the earth.

THE AEROSPACE INDUSTRY

Engineers and researchers also use supercomputers to design, develop, and test aerospace vehicles and related equipment. In particular, computational fluid dynamics, which is dependent upon supercomputing, enables engineers to simulate the flow of air and fluid around proposed design shapes and then modify designs accordingly. The simulations performed using this application are valuable in eliminating some of the traditional wind tunnel tests used in evaluating the aerodynamics of airplanes. Wind tunnels are expensive to build and maintain, require costly construction of physical models, and cannot reliably detect certain airflow phenomena. Supercomputer-based design has thus resulted in significant time and cost savings, as well as better designs, for the aerospace industry.

Lockheed Aerospace used computational fluid dynamics on a supercomputer to develop a computer model of the Advanced Tactical Fighter for the U.S. Air Force. By using this approach, Lockheed was able to display a full-vehicle computer model of the fighter after approximately 5 hours of supercomputer processing time. This approach allowed Lockheed to reduce the amount of wind-tunnel testing by 80 hours, resulting in savings of about half a million dollars.

The Boeing Aircraft Company used a Cray 1S-2000 supercomputer to redesign the 17-year old 737-200 aircraft in the early 1980s. Aiming to create a more fuel-efficient plane, Boeing decided to make the body design longer and replace the engines with larger but more efficient models. To determine the appropriate placement of these new engines, Boeing used the supercomputer to simulate a wind-tunnel test. The results of this simulation--which were much more detailed than would have been available from an actual wind-tunnel test--allowed the engineers to solve the engine placement problem and create a more fuel-efficient aircraft.

THE AUTOMOBILE INDUSTRY

Automobile manufacturers have been using supercomputers increasingly since 1985 as a design tool to make cars safer, lighter, more economical, and better built. Further, the use of supercomputers has allowed the automobile industry to achieve these design improvements at significant savings.

One supercomputer application receiving increasing interest is automobile crash-simulation. To meet federally mandated crash-worthiness requirements, the automobile industry crashes large numbers of pre-prototype vehicles head-on at 30 miles per hour into rigid barriers. Vehicles for such tests can cost from $225,000 to $750,000 each. Crash simulation using supercomputers provides more precise engineering information, however, than is typically available from actually crashing vehicles. In addition, using supercomputers to perform this type of structural analysis reduces the number of actual crash tests required by 20 to 30 percent, saving the companies millions of dollars each year. Simulations such as this were not practical prior to the development of vector supercomputing because of the volume and complexity of data involved.

Automobile companies credit supercomputers with improving automobile design in other ways as well. For example, Chrysler Corporation engineers use linear analysis and weight optimization software on a Cray X-MP supercomputer to improve the design of its vehicles. The resulting designs--which, according to a Chrysler representative, would not have been practical without a supercomputer--will allow Chrysler to achieve an annual reduction of about $3 million in the cost of raw materials for manufacturing its automobiles. In addition, one automobile's body was made 10 percent more rigid (which will improve ride and handling) and 11 percent lighter (which will improve fuel efficiency). According to the Chrysler representative, this is typical of improvements that are being achieved through the use of its supercomputer.

THE CHEMICAL AND PHARMACEUTICAL INDUSTRIES

Supercomputers play a growing role in the chemical and pharmaceutical industries, although their use is still in its infancy. From computer-assisted molecular design to synthetic materials research, companies in these fields increasingly rely on supercomputers to study critical design parameters and more quickly and accurately interpret and refine experimental results. Industry representative told us that, as a result, the use of supercomputing will result in new discoveries that may not have been possible otherwise.

The pharmaceutical industry is beginning to use supercomputers as a research tool in developing new drugs. Development of a new drug may require up to 30,000 compounds being synthesized and screened, at a cost of about $5,000 per synthesis. As such, up to $150 million, before clinical testing and other costs, may be invested in discovering a new drug, according to an E.I. du Pont de Nemours and Company representative. Scientists can now eliminate some of this testing by using simulation on a supercomputer. The supercomputer analyzes and interprets complex data obtained from experimental measurements. Then, using workstations, scientists can construct three-dimensional models of the large, complex human proteins and enzymes on the computer screen and rotate these images to gain clues regarding biological activity and reactions to various potential drugs.

Computer simulations are also being used in the chemical industry to replace or enhance more traditional laboratory measurements. Du Pont is currently working to develop replacements for chlorofluorocarbons, compounds used as coolants for refrigerators and air conditioners, and as cleansing agents for electronic equipment. These compounds are generally thought to contribute to the ozone depletion of the atmosphere and are being phased out. Du Pont is designing a new process to produce substitute compounds in a safe and cost-effective manner. These substitutes will be more reactive in the atmosphere and subject to faster decomposition. Du Pont is using a supercomputer to calculate the thermodynamic data needed for developing the process. These calculations can be completed by the supercomputer in a matter of days, at an approximate cost of $2,000 to $5,000. Previously, such tests--using experimental measurements conducted in a laboratory--would require up to 3 months to conduct, at a cost of about $50,000. Both the cost and time required would substantially limit the amount of testing done.

BARRIERS TO GREATER USE OF SUPERCOMPUTERS

These examples demonstrate the significant advantages in terms of cost savings, product improvements, and competitive opportunity that can be realized through supercomputer use. However, such use is still concentrated in only a few industries. Our industry contacts identified significant, interrelated barriers that individually or collectively, limit more widespread use of supercomputers.

Cost. Supercomputers are expensive. A supercomputer's cost of between $1 million and $30 million does not include the cost of software development, maintenance, or trained staff.

Cultural resistance. Simulation on supercomputers can not only reduce the physical testing, measurement, and experimentation, but can provide information that cannot otherwise be attained. For many scientists and managers this represents a dramatic break with past training, experience, generally accepted methods, or common doctrine. For some, such a major shift in research methodology is difficult to accept. These new methods are simply resisted or ignored.

Lack of application software. Supercomputers can be difficult to use. For many industry applications, reliable software has not yet been developed. This is particularly true for massively parallel supercomputers.

Lack of trained scientists in supercomputing. Between 1970 and 1985, university students and professors performed little of their research on supercomputers. For 15 years, industry hired students from universities who did not bring supercomputing skills and attitudes into their jobs. Now, as a result, many high-level scientists, engineers, and managers in industry have little or no knowledge of supercomputing.

In conclusion, our work to date suggests that the use of supercomputers has made substantial contributions in key U.S. industries. While our statement has referred to benefits related to cost reduction and time savings, we believe that supercomputers will increasingly be used to gain substantive competitive advantage. Supercomputers offer the potential--still largely untapped--to develop new and better products more quickly. This potential is just beginning to be explored, as are ways around the barriers that prevent supercomputers from being more fully exploited.

SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS MARKUP OF H.R. 656, THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

WEDNESDAY, APRIL 10, 1991

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 11:44 a.m. in room 2318, Rayburn House Office Building, Hon. Tim Valentine [chairman of the subcommittee] presiding.

Mr. VALENTINE. Now we will go on to the second bill on today's agenda, an amendment in the nature of a substitute to H.R. 656, which was introduced by the chairman of the full committee, Chairman Brown. It authorizes the High Performance Computing and Communications Program, presented as a supplement to the Administration's fiscal year 1992 budget.

The subcommittee print before the subcommittee members authorizes a five-year program for research and development on advanced computer hardware and software technologies, and advanced computer networks.

The United States currently leads the world in the development and use of high performance computing, but we are being challenged by foreign competitors. This program will promote continued research and development of high performance computing hardware and software technologies. It will transform our current scientific computing networks into high capacity National Research and Education Networks, NREN.

Also, the program will expand the number of researchers, educators, students, and industrial users with training in and access to high performance computing.

The amounts authorized for fiscal year 1992 reflect the President's requests for the participating agencies, and the out year authorizations are numbers provided by the Administration.

This subcommittee has worked closely with the Administration and many others in drafting this legislation. Yesterday, OSTP indicated to us that they will have further suggestions. We will continue to work closely with OSTP during later stages of deliberation on this bill to incorporate any changes that could improve the legislation— subject, of course, to the vote of the full committee.

[The subcommittee print follows:]

VALENT010

AMENDMENT IN THE NATURE OF A SUBSTITUTE TO H.R. 656
OFFERED BY MR. VALENTINE

Strike all after the enacting clause and insert in lieu thereof the following:

SECTION 1. SHORT TITLE.

This Act may be cited as the ``High-Performance Computing Act of 1991''.

SEC. 2. FINDINGS AND PURPOSE.

(a) FINDINGS.--The Congress finds the following:

(1) Advances in computer science and technology are vital to the Nation's prosperity, national and economic security, and scientific advancement.

(2) The United States currently leads the world in the development and use of high-performance computing for national security, industrial productivity, and science and engineering, but that lead is being challenged by foreign competitors.

(3) Further research, improved computer research networks, and more effective technology transfer from government to industry are necessary for the United States to fully reap the benefits of high-performance computing.

(4) Several Federal agencies have ongoing high-performance computing programs, but improved interagency coordination, cooperation, and planning could enhance the effectiveness of these programs.

(5) A 1989 report by the Office of Science and Technology Policy outlining a research and development strategy for high-performance computing provides a framework for a multiagency high-performance computing program.

(6) Such a program would provide American researchers and educators with the computer and information resources they need, while demonstrating how advanced computers, high-speed networks, and electronic data bases can improve the national information infrastructure for use by all Americans.

(b) PURPOSE.--It is the purpose of Congress in this Act to help ensure the continued leadership of the United States in high-performance computing and its applications through--

(1) the expansion of Federal support for research, development, and application of high-performance computing in order to--

(A) establish a high-capacity national research and education computer network;

(B) expand the number of researchers, educators, and students with training in high-performance computing and access to high-performance computing resources;

(C) develop an information infrastructure of data bases, services, access mechanisms, and research facilities which is available for use through such a national network;

(D) stimulate research on software technology;

(E) promote the more rapid development and wider distribution of computer software tools and applications software;

(F) accelerate the development of computer systems and subsystems;

(G) transfer emerging high-performance computing hardware and software technologies into centers and universities for the application to Grand Challenges;

(H) ensure that appropriate security controls are implemented;

(I) promote the inclusion of high-performance computing into education at all levels; and

(J) encourage cooperative programs between industry and high-performance computing centers to enhance industrial competitiveness; and

(2) the improvement of planning and coordination of Federal research and development on high-performance computing.

SEC. 3. DEFINITIONS.

As used in this Act, the term--

(1) ``Council'' means the Federal Coordinating Council for Science, Engineering, and Technology;

(2) ``Director'' means the Director of the Office of Science and Technology Policy; and

(3) ``Grand Challenge'' means a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

SEC. 4. MISCELLANEOUS PROVISIONS.

(a) NONAPPLICABILITY.--Except to the extent the appropriate Federal agency or department head determines, the provisions of this Act shall not apply to--

(1) programs or activities regarding computer systems that process classified information; or

(2) computer systems the function, operation, or use of which are those delineated in paragraphs (1) through (5) of section 2315(a) of title 10, United States Code.

(b) ACQUISITION OF PROTOTYPE AND EARLY PRODUCTION MODELS.--Where appropriate, and in accordance with Federal contracting law, Federal agencies and departments shall procure prototype or early production models of new high-performance computer systems and subsystems to stimulate hardware and software development.

SEC. 5. NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM.

The National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq.) is amended by adding at the end the following new title:

``TITLE VII--NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM

``NATIONAL HIGH-PERFORMANCE COMPUTING PLAN

``SEC. 701. (a)(1) The President, through the Federal Coordinating Council for Science, Engineering, and Technology (hereafter in this title referred to as the `Council'), shall, in accordance with the provisions of this title--

``(A) develop and implement a National High-Performance Computing Plan (hereafter in this title referred to as the `Plan'); and

``(B) provide for interagency coordination of the implementation of the Plan.

The Plan shall contain recommendations for a 5-year national effort and shall be submitted to the Congress within 1 year after the date of enactment of this title. The Plan shall be resubmitted upon revision at least once every 2 years thereafter.

``(2) The Plan shall--

``(A) establish the goals and priorities for a Federal high-performance computing program for the fiscal year in which the Plan (or revised Plan) is submitted and the succeeding 4 fiscal years;

``(B) set forth the role of each Federal agency and department in implementing the Plan; and

``(C) describe the levels of Federal funding for each agency and department and specific activities, including education, research activities, hardware and software development, establishment of a national multi-gigabit-per-second research and education computer network, to be known as the National Research and Education Network, and acquisition and operating expenses for computers and computer networks, required to achieve the goals and priorities established under subparagraph (A).

``(3) The Plan shall address, where appropriate, the relevant programs and activities of--

``(A) the National Science Foundation;

``(B) the Department of Commerce, particularly the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Telecommunications and Information Administration;

``(C) the National Aeronautics and Space Administration;

``(D) the Department of Defense, particularly the Defense Advanced Research Projects Agency;

``(E) the Department of Energy;

``(F) the Department of Health and Human Services, particularly the National Institutes of Health and the National Library of Medicine;

``(G) the Environmental Protection Agency;

``(H) the Department of Education;

``(I) the Department of Agriculture, particularly the National Agricultural Library; and

``(J) such other agencies and departments as the President or the Chairman of the Council considers appropriate.

``(4) In addition, the Plan shall take into consideration the present and planned activities of the Library of Congress, as the Librarian of Congress considers appropriate.

``(5) The Plan shall identify how agencies and departments can collaborate to--

``(A) ensure interoperability among computer networks run by the agencies and departments;

``(B) increase software productivity, capability, portability, and reliability;

``(C) expand efforts to improve, document, and evaluate unclassified public-domain software developed by federally funded researchers and other software, including federally funded educational and training software;

``(D) cooperate, where appropriate, with industry in the development and exchange of software;

``(E) distribute software among the agencies and departments;

``(F) distribute federally funded software to State and local governments, industry, and universities;

``(G) ensure accessibility to Federal energy data bases and information;

``(H) accelerate the development of high-performance computer systems, subsystems, and associated software;

``(I) provide the technical support and research and development of high-performance computer software and hardware needed to address Grand Challenges in astrophysics, geophysics, engineering, materials, biochemistry, plasma physics, weather and climate forecasting, and other fields;

``(J) provide for educating and training additional undergraduate and graduate students in software engineering, computer science, library and information science, and computational science; and

``(K) identify agency and department rules, regulations, policies, and practices which can be changed to significantly improve utilization of Federal high-performance computing and network facilities, and make recommendations to such agencies and departments for appropriate changes.

``(6) The Plan shall address the security requirements and policies necessary to protect Federal research computer networks and information resources accessible through Federal research computer networks. The Plan shall identify research required to establish security standards for high-performance computers and networks. Agencies and departments identified in the Plan shall define and implement a security plan consistent with the Plan.

``(b) The Council shall--

``(1) serve as lead entity responsible for development of the Plan and interagency coordination of the implementation of the Plan;

``(2) coordinate the high-performance computing research and development activities of Federal agencies and departments and report at least annually to the President, through the Chairman of the Council, on any recommended changes in agency or departmental roles that are needed to better implement the Plan;

``(3) review, prior to the President's submission to the Congress of the annual budget estimate, each agency and departmental budget estimate in the context of the Plan and make the results of that review available to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget; and

``(4) consult and coordinate with Federal agencies and departments, and academic, State, industry, and other appropriate groups conducting research on and using high-performance computing.

``(c) The Director of the Office of Science and Technology Policy shall establish a High-Performance Computing Advisory Panel consisting of prominent representatives from industry and academia who are specially qualified to provide the Council with advice and information on high-performance computing. The Panel shall provide the Council with an independent assessment of--

``(1) progress made in implementing the Plan;

``(2) the need to revise the Plan;

``(3) the balance between the components of the Plan;

``(4) whether the research and development funded under the Plan is helping to maintain United States leadership in computing technology; and

``(5) other issues identified by the Director.

``(d)(1) Each appropriate Federal agency and department involved in high-performance computing shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report to the Office identifying each element of its high-performance computing activities, which--

``(A) specifies whether each such element (i) contributes primarily to the implementation of the Plan, or (ii) contributes primarily to the achievement of other objectives but aids Plan implementation in important ways; and

‘‘(B) states the portion of its request for appropriations that is allocated to each such element.

‘‘(2) The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency and departmental responsibilities set forth in the Plan, and shall include, in the President's annual budget estimate, a statement of the portion of each appropriate agency or department's annual budget estimate that is allocated to each element of such agency or department's high-performance computing activities.

‘‘(e) As used in this section, the term ‘Grand Challenge’ means a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

‘‘ANNUAL REPORT

‘‘SEC. 702. The Chairman of the Council shall prepare and submit to the President and the Congress, not later than March 1 of each year, a report on the activities conducted pursuant to this title during the preceding fiscal year, including--

‘‘(1) a summary of the achievements of Federal high-performance computing research and development efforts during that preceding fiscal year;

"(2) an analysis of the progress made toward achieving the goals and priorities of the Plan;

"(3) a copy and summary of the Plan and any changes made in such Plan;

"(4) a summary of appropriate agency and departmental budgets for high-performance computing activities for that preceding fiscal year;

"(5) an analysis of the security issues affecting implementation of the Plan; and

"(6) any recommendations regarding additional action or legislation which may be required to assist in carrying out this title.".

SEC. 6. NATIONAL RESEARCH AND EDUCATION NETWORK.

(a) ESTABLISHMENT.--In accordance with the Plan developed under section 701 of the National Science and Technology Policy, Organization, and Priorities Act of 1976, as added by section 5 of this Act, the National Science Foundation, in cooperation with the Department of Defense, the Department Energy, the Department of Commerce, the National Aerona and Space Administration, and other appropriate agenc shall provide for the establishment of a national multi-gigabit-per-second research and education network by 1996, to be known as the National R

Education Network (hereafter in this Act referred to as the ``Network''), which shall link government, industry, and research and education institutions.

(b) ACCESS.--The Network shall provide users with appropriate access to high-performance computers, computer data bases, other research facilities, and libraries.

(c) NETWORK CHARACTERISTICS.--The Network shall--

(1) be developed in close cooperation with the computer, telecommunications, and information industries;

(2) be designed and developed with the advice of potential users in government, industry, and research and education institutions;

(3) be established in a manner which fosters and maintains competition and private sector investment in high speed data networking within the telecommunications industry;

(4) be established in a manner which promotes research and development leading to deployment of commercial data communications and telecommunications standards;

(5) be designed to ensure the continued application of laws that provide network and information resources security measures, that protect copyright and intellectual property rights, or that control access to data bases;

(6) where technically feasible, have accounting mechanisms which allow, where appropriate, users or groups of users to be charged for their usage of the Network and copyrighted materials available over the Network; and

(7) be phased into commercial operation as commercial networks can meet the networking needs of American researchers and educators.

(d) DEPARTMENT OF DEFENSE RESPONSIBILITY.--The Department of Defense, through the Defense Advanced Research Projects Agency, shall be lead agency for research and development of advanced fiber optics technology, switches, and protocols needed to develop the Network.

(e) NATIONAL SCIENCE FOUNDATION RESPONSIBILITY.--Within the Federal Government, the National Science Foundation shall have primary responsibility for connecting colleges, universities, and libraries to the Network.

(f) ROLE OF THE COUNCIL.--(1) The Council, within 1 year after the date of enactment of this Act and consistent with the Plan developed under section 701 of the National Science and Technology Policy, Organization, and Priorities Act of 1976, as added by section 5 of this Act, shall--

(A) develop goals, strategy, and priorities for the Network;

(B) identify the roles of Federal agencies and departments implementing the Network;

(C) provide a mechanism to coordinate the activities of Federal agencies and departments in deploying the Network;

(D) oversee the operation and evolution of the Network;

(E) manage the connections between computer networks of Federal agencies and departments;

(F) develop conditions for access to the Network; and

(G) identify how existing and future computer networks of Federal agencies and departments could contribute to the Network.

(2) The President shall report to Congress within 1 year after the date of enactment of this Act on the implementation of this subsection.

(g) INTERAGENCY COORDINATION STANDARDS AND GUIDELINES.--In addition to other agency activities associated with the establishment of the Network, the National Institute of Standards and Technology, the National Science Foundation, and the Defense Advanced Research Project Agency shall adopt a common set of standards and guidelines to provide interoperability, common user interfaces to systems, and enhanced security for the Network.

(h) USE OF GRANT FUNDS.--The National Science Foundation, the National Aeronautics and Space Administration, the

Department of Energy, the Department of Defense, the Department of Commerce, the Department of the Interior, the Department of Agriculture, the Department of Health and Human Services, and the Environmental Protection Agency may allow recipients of Federal research grants to use grant funds to pay for computer networking expenses.

(i) REPORT.--Within 1 year after the date of enactment of this Act, the Director, through the Council, shall report to the Congress on--

(1) effective mechanisms for providing operating funds for the maintenance and use of the Network, including user fees, industry support, and continued Federal investment;

(2) plans for the eventual commercialization of the Network;

(3) how commercial information service providers could be charged for access to the Network;

(4) the technological feasibility of allowing commercial information service providers to use the Network and other federally funded research networks;

(5) how Network users could be charged for such commercial information services;

(6) how to protect the copyrights of material distributed over the Network; and

(7) appropriate policies and standards to ensure the

security of resources available on the Network and to protect the privacy of users of networks.

SEC. 7. ROLE OF THE NATIONAL SCIENCE FOUNDATION.

(a) GENERAL RESPONSIBILITIES.--The National Science Foundation shall provide funding to enable researchers to access high-performance computers. Prior to deployment of the Network, the National Science Foundation shall maintain, expand, and upgrade its existing computer networks. The responsibilities of the National Science Foundation may include promoting development of information services and data bases available over such computer networks; facilitation of the documentation, evaluation, and distribution of research software over such computer networks; encouragement of continued development of innovative software by industry; and promotion of science and engineering education.

(b) INFORMATION SERVICES.--The National Science Foundation shall, in cooperation with other appropriate agencies and departments, promote the development of information services that could be provided over the Network established under section 6. These services shall include the provision of directories of users and services on computer networks, data bases of unclassified Federal scientific data, training of users of data bases and networks, access to commercial information services to users of the Network, and technology to support computer-based collaboration that allows researchers around the Nation to share information and instrumentation.

(c) AUTHORIZATION OF APPROPRIATIONS.--There are authorized to be appropriated to the National Science Foundation for the purposes of this Act $46,000,000 for fiscal year 1992, of which $15,000,000 shall be for purposes of section 6; $88,000,000 for fiscal year 1993, of which $25,000,000 shall be for purposes of section 6; $145,000,000 for fiscal year 1994, of which $55,000,000 shall be for purposes of section 6; $172,000,000 for fiscal year 1995, of which $50,000,000 shall be for purposes of section 6; and $199,000,000 for fiscal year 1996, of which $50,000,000 shall be for purposes of section 6.

SEC. 8. ROLE OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

(a) GENERAL RESPONSIBILITIES.--In accordance with the Plan developed under section 701 of the National Science and Technology Policy, Organization, and Priorities Act of 1976, as added by section 5 of this Act, the National Aeronautics and Space Administration shall conduct basic and applied research in high-performance computing, particularly in the field of computational science, with emphasis on aeronautics and the processing of remote sensing and space science data.

(b) AUTHORIZATION OF APPROPRIATIONS.--There are authorized to be appropriated to the National Aeronautics and Space Administration for the purposes of this Act $22,000,000 for fiscal year 1992, $45,000,000 for fiscal year 1993, $67,000,000 for fiscal year 1994, $89,000,000 for fiscal year 1995, and $115,000,000 for fiscal year 1996.

SEC. 9. ROLE OF THE DEPARTMENT OF COMMERCE.

(a) GENERAL RESPONSIBILITIES.--The National Institute of Standards and Technology shall adopt standards and guidelines, and develop measurement techniques and test methods, for the interoperability of high-performance computers in networks and for common user interfaces to systems. In addition, the National Institute of Standards and Technology shall be responsible for developing benchmark tests and standards for high-performance computers and software.

(b) STUDY OF IMPACT OF REGULATIONS.--(1) The Secretary of Commerce shall conduct a study to evaluate the impact of Federal procurement regulations which require that contractors providing software to the Federal Government share the rights to proprietary software development tools that the contractors use to develop the software, including a determination of whether such regulations discourage development of improved software development tools and techniques.

(2) The Secretary of Commerce shall, within 1 year after

the date of enactment of this Act, report to the Congress regarding the results of the study conducted under paragraph (1).

(c) High-Performance Computing and Network Security.--The National Institute of Standards and Technology shall conduct research needed to support the adoption of security standards for high-performance computer systems and networks. In accomplishing this objective, the National Institute of Standards and Technology shall utilize whenever possible recognized centers of expertise that may exist in the academic and national laboratory communities.

(d) Authorization of Appropriations.--There are authorized to be appropriated to the National Institute of Standards and Technology for the purposes of this Act $3,000,000 for fiscal year 1992, $5,000,000 for fiscal year 1993, $7,000,000 for fiscal year 1994, $9,000,000 for fiscal year 1995, and $11,000,000 for fiscal year 1996.

Mr. **Valentine**. Now I recognize the ranking member of the subcommittee, Mr. Lewis, for any comments that he has at this time.

Mr. **Lewis**. I have no comments, Mr. Chairman. They were in my opening statement.

Mr. **Valentine**. Are there other members of the subcommittee who have any statements to make at this time?

[No response.]

Mr. **Valentine**. The Chair asks unanimous consent that the subcommittee print before you be considered as the original text of H.R. 656 for purposes of this markup.

Mr. **Lewis**. So moved, Mr. Chairman.

Mr. **Valentine**. There being no objection, we will proceed.

The bill is open for discussion.

[No response.]

Mr. **Valentine**. If there is no discussion, the bill is now open for amendment.

Let me say here that we don't want to proceed to fast. If anybody has any questions, we have there the gentleman with all of the answers.

Mr. **Roemer**. Mr. Chairman, I do have one question.

I would like to salute you for your expeditious movement on this bill. Would now be the appropriate time for me to be a co-sponsor on this particular legislation?

Mr. **Valentine**. It would, indeed.

Mr. **Roemer**. All right, Mr. Chairman. Please put me down.

Mr. **Valentine**. Your name will appear in the appropriate place in the Book of Life.

Mr. **Roemer**. Thank you, sir.

[Laughter.]

Mr. **Roemer**. I've got to record it somewhere.

Mr. **Valentine**. If there is—I don't know if I said this or not—if there is no further discussion, the bill is now open to amendment.

[No response.]

Mr. **Valentine**. If there are no amendments, the Chair recognizes the gentleman from Florida, Mr. Lewis, for a motion.

Mr. **Lewis**. Mr. Chairman, I move that the subcommittee report the bill, H.R. 656, as amended. Furthermore, I move to instruct the staff to prepare the subcommittee report, to make technical and conforming amendments, and that the chairman take all necessary steps to bring the bill, High Performance Computing, before the full committee for consideration.

Mr. **Valentine**. You have heard the motion. Is there any discussion?

[No response.]

Mr. **Valentine**. If not, all in favor of the motion say aye.

[Chorus of ayes.]

Mr. **Valentine**. Those opposed, no.

[No response.]

Mr. **Valentine**. The ayes have it and the bill is adopted. Thank you.

SUBCOMMITTEE ON SCIENCE MARKUP OF H.R. 656, THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

WEDNESDAY, April 17, 1991

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Science,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:40 a.m., in room 2325, Rayburn House Office Building, Hon. Rick Boucher [chairman of the subcommittee] presiding.

Mr. Boucher. We will proceed now to the second matter before the subcommittee this morning, and the chair now calls up H.R. 656, the High Performance Computing Act of 1991. Both the original bill, as introduced by the gentleman from California, Mr. Brown, and an amendment in the nature of a substitute, which has been constructed by the subcommittee staff, are before the subcommittee members.

[The amendment in the nature of a substitute follows:]

TB1004

AMENDMENT IN THE NATURE OF A SUBSTITUTE
TO H.R. 656
OFFERED BY MR. BOUCHER

Srike all after the enacting clause and insert in lieu thereof the following:

SECTION 1. SHORT TITLE.

This Act may be cited as the ``High-Performance Computing Act of 1991''.

SEC. 2. FINDINGS AND PURPOSE.

(a) FINDINGS.--The Congress finds the following:

(1) Advances in computer science and technology are vital to the Nation's prosperity, national and economic security, and scientific advancement.

(2) The United States currently leads the world in the development and use of high-performance computing for national security, industrial productivity, and science and engineering, but that lead is being challenged by foreign competitors.

(3) Further research and development, expanded educational programs, improved computer research networks, and more effective technology transfer from government to industry are necessary for the United

States to fully reap the benefits of high-performance computing.

(4) Several Federal agencies have ongoing high-performance computing programs, but long-term interagency coordination, cooperation, and planning could enhance the effectiveness of these programs.

(5) A 1989 report and a 1991 report entitled ``Grand Challenges: High-Performance Computing and Communications'' by the Office of Science and Technology Policy outlining a research and development strategy for high-performance computing provides a framework for a multiagency high-performance computing program.

(6) Such a program would provide American researchers and educators with the computer and information resources they need, while demonstrating how advanced computers, high-speed networks, and electronic data bases can improve the national information infrastructure for use by all Americans.

(b) PURPOSE.--It is the purpose of Congress in this Act to help ensure the continued leadership of the United States in high-performance computing and its applications through--

(1) the expansion of Federal support for research, development, and application of high-performance computing in order to--

(A) establish a high-capacity national research and education computer network;

(B) expand the number of researchers, educators, and students with training in high-performance computing and access to high-performance computing resources;

(C) promote the further development of an information infrastructure of data bases, services, access mechanisms, and research facilities which is available for use through such a national network;

(D) stimulate research on software technology;

(E) promote the more rapid development and wider distribution of computer software tools and applications software;

(F) accelerate the development of computer systems and subsystems;

(G) ensure that emerging high-performance computing hardware and software technologies are available to researchers for the application to Grand Challenges;

(H) promote the inclusion of high-performance computing into educational institutions at all levels;

(I) ensure that appropriate security controls are implemented; and

(J) encourage cooperative programs between industry and high-performance computing centers to enhance industrial competitiveness; and

(2) the improvement of planning and coordination of Federal research and development on high-performance computing.

SEC. 3. DEFINITIONS.

As used in this Act, the term--

(1) ``Council'' means the Federal Coordinating Council for Science, Engineering, and Technology;

(2) ``Director'' means the Director of the Office of Science and Technology Policy; and

(3) ``Grand Challenge'' means a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

SEC. 4. MISCELLANEOUS PROVISIONS.

(a) NONAPPLICABILITY.--Except to the extent the appropriate Federal agency or department head determines, the provisions of this Act shall not apply to--

(1) programs or activities regarding computer systems that process classified information; or

(2) computer systems the function, operation, or use of which are those delineated in paragraphs (1) through (5) of section 2315(a) of title 10, United States Code.

(b) ACQUISITION OF PROTOTYPE AND EARLY PRODUCTION

MODELS.--In accordance with the Plan developed under section 5, and in accordance with Federal contracting law, Federal agencies and departments shall purchase or lease prototype or early production models of new high-performance computer systems and subsystems to stimulate hardware and software development. Items of computing equipment acquired under this subsection shall be considered research computers for purposes of applicable acquisition regulations.

SEC. 5. NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM.

(a) NATIONAL HIGH-PERFORMANCE COMPUTING PLAN.--(1) The President, through the Council, shall--

(A) develop and implement a National High-Performance Computing Plan (hereafter in this section referred to as the ``Plan''); and

(B) provide for interagency coordination of the implementation of the Plan.

The Plan shall contain recommendations for a 5-year national effort and shall be submitted to the Congress along with the submission of the President's annual budget request for fiscal year 1993. The Plan shall be revised and resubmitted annually thereafter along with the President's annual budget requests.

(2) The Plan shall--

(A) establish the goals and priorities for a Federal high-performance computing program for the fiscal year in which the Plan (or revised Plan) is submitted and the succeeding 4 fiscal years;

(B) set forth the role of each Federal agency and department in implementing the Plan; and

(C) describe the levels of Federal funding for each agency and department and specific activities, including education, research activities, hardware and software development, support for the establishment of a national multi-gigabit-per-second research and education computer network, to be known as the National Research and Education Network, and acquisition and operating expenses for computers and operating expenses for the Federal Government's use of computer networks, required to achieve the goals and priorities established under subparagraph (A).

(3) Accompanying the Plan, and each revision thereof, shall be--

(A) a summary of the achievements of Federal high-performance computing research and development efforts during the preceding fiscal year;

(B) an analysis of the progress made toward achieving the goals and priorities established under the Plan;

(C) any recommendations regarding additional action or legislation which may be required to assist in achieving the goals and priorities established under the

Plan; and

(D) an analysis of the security issues affecting implementation of the Plan.

(4) The Plan shall address, where appropriate, the relevant programs and activities of--

(A) the National Science Foundation;

(B) the Department of Commerce, particularly the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Telecommunications and Information Administration;

(C) the National Aeronautics and Space Administration;

(D) the Department of Defense, particularly the Defense Advanced Research Projects Agency;

(E) the Department of Energy;

(F) the Department of Health and Human Services, particularly the National Institutes of Health and the National Library of Medicine;

(G) the Environmental Protection Agency;

(H) the Department of Education;

(I) the Department of Agriculture, particularly the National Agricultural Library; and

(J) such other agencies and departments as the President or the Chairman of the Council considers appropriate.

(5) In addition, the Plan shall take into consideration the present and planned activities of the Library of Congress, as the Librarian of Congress considers appropriate.

(6) The Plan shall identify how agencies and departments can collaborate to--

(A) ensure interoperability among computer networks operated by or receiving financial support from the Federal Government;

(B) increase software productivity, capability, portability, and reliability;

(C) expand efforts to improve, document, and evaluate unclassified public-domain software developed by federally funded researchers and other software, including federally funded educational and training software;

(D) cooperate, where appropriate, with industry in the development and exchange of software;

(E) distribute software among the agencies and departments;

(F) distribute federally funded software to State and local governments, industry, and universities;

(G) ensure accessibility to Federal agency data bases and information;

(H) accelerate the development of high-performance computer systems, subsystems, and associated software;

(I) provide the technical support and research and development of high-performance computer software and hardware needed to address Grand Challenges in astrophysics, geophysics, engineering, materials, biochemistry, plasma physics, weather and climate forecasting, and other fields;

(J) provide for educating and training additional undergraduate and graduate students in software engineering, computer science, library and information science, and computational science;

(K) demonstrate use of the National Research and Education Network for educational uses at all levels; and

(L) identify agency and department rules, regulations, policies, and practices which can be changed to significantly improve utilization of Federal high-performance computing and network facilities, and make recommendations to such agencies and departments for appropriate changes.

(7) The Plan shall address the security requirements and policies necessary to protect Federal research computer networks and information resources accessible through Federal research computer networks. The Plan shall identify research required to establish security standards for high-performance computers and networks. Agencies and departments identified

in the Plan shall define and implement a security plan consistent with the Plan.

(b) ROLE OF THE COUNCIL.--The Council shall--

(1) serve as lead entity responsible for development of the Plan and interagency coordination of the implementation of the Plan;

(2) coordinate the high-performance computing research and development activities of Federal agencies and departments and report at least annually to the President, through the Chairman of the Council, on any recommended changes in agency or departmental roles that are needed to better implement the Plan;

(3) review, prior to the President's submission to the Congress of the annual budget estimate, each agency and departmental budget estimate in the context of the Plan and make the results of that review available to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget; and

(4) consult and coordinate with Federal agencies and departments, and academic, State, industry, and other appropriate groups conducting research on and using high-performance computing.

(c) HIGH-PERFORMANCE COMPUTING ADVISORY PANEL.--The Director shall establish a High-Performance Computing

Advisory Panel consisting of prominent representatives from the private sector, including the research, education, and library communities, network providers, and industry, who are specially qualified to provide the Council with advice and information on high-performance computing. The Council shall consider the recommendations of the Panel in developing and revising the Plan. The Panel shall provide the Council with an independent assessment of--

(1) progress made in implementing the Plan;

(2) the need to revise the Plan;

(3) the balance between the components of the Plan;

(4) whether the research and development funded under the Plan is helping to maintain United States leadership in computing technology; and

(5) other issues identified by the Director.

(d) OFFICE OF MANAGEMENT AND BUDGET.--(1) Each appropriate Federal agency and department involved in high-performance computing shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report to the Office identifying each element of its high-performance computing activities, which--

(A) specifies whether each such element (i) contributes primarily to the implementation of the Plan, or (ii) contributes primarily to the achievement of other objectives but aids Plan implementation in important ways; and

(B) states the portion of its request for appropriations that is allocated to each such element.

(2) The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency and departmental responsibilities set forth in the Plan, and shall include, in the President's annual budget estimate, a statement of the portion of each appropriate agency or department's annual budget estimate that is allocated to each element of such agency or department's high-performance computing activities.

SEC. 6. NATIONAL RESEARCH AND EDUCATION NETWORK.

(a) ESTABLISHMENT.--In accordance with the Plan developed under section 5, the National Science Foundation, in cooperation with the Department of Defense, the Department of Energy, the Department of Commerce, the National Aeronautics and Space Administration, and other appropriate agencies, shall coordinate activities supporting the broad deployment and use of a national multi-gigabit-per-second research and education computer network, to be known as the National Research and Education Network (hereafter in this Act referred to as the ``Network''), which shall link research institutions and educational institutions, government, and industry in every State. For purposes of this section, agency activities may include research and development, development of network applications important for research and education, and contracting for services, but shall not include purchasing switches, optical fiber, or any other networking hardware for purposes other than research and development.

(b) ACCESS.--Federal agencies shall work with State and local agencies, libraries, educational institutions and organizations, and private network service providers in order to ensure that the researchers, educators, and students have access to the Network. The Network shall provide users with appropriate access to high-performance computers, computer data bases, other research facilities, and libraries. The Network shall provide access, to the extent practicable, to electronic information resources maintained by libraries, research facilities, publishers, and affiliated organizations.

(c) NETWORK CHARACTERISTICS.--The Network shall--

(1) be developed jointly with the computer, telecommunications, and information industries;

(2) be designed, developed, and operated in collaboration with potential users in government, industry, and research institutions and educational institutions;

(3) be designed, developed, and operated in a manner which fosters and maintains competition and private sector investment in high speed data networking within

the telecommunications industry;

(4) be designed, developed, and operated in a manner which promotes research and development leading to deployment of commercial data communications and telecommunications standards;

(5) be designed to ensure the continued application of laws that provide network and information resources security measures that protect copyright and intellectual property rights, or that control access to data bases; and

(6) have accounting mechanisms which allow users or groups of users to be charged for their usage of copyrighted materials available over the Network and, where appropriate and technically feasible, for their usage of the Network.

(d) DEPARTMENT OF DEFENSE RESPONSIBILITY.--The Department of Defense, through the Defense Advanced Research Projects Agency, shall be lead agency for coordinating activities in gigabit network technology research, including development of new protocols and switch and transmission technologies.

(e) NATIONAL SCIENCE FOUNDATION RESPONSIBILITY.--Within the Federal Government, the National Science Foundation shall be responsible for managing the Network according to policies established by the Council under subsection (f).

(f) ROLE OF THE COUNCIL.--The Council, within 1 year after the date of enactment of this Act and consistent with the Plan developed under section 5, shall--

(1) develop goals, strategy, and priorities for the Network;

(2) identify the roles of Federal agencies and departments implementing the Network;

(3) establish policies for management and access to the Network;

(4) oversee the operation and evolution of the Network;

(5) ensure the connectivity among computer networks of Federal agencies and departments;

(6) coordinate the activities of Federal agencies and departments, States, and public and private network service providers in deploying the Network; and

(7) identify how existing and future computer networks of Federal agencies and departments could contribute to the Network.

(g) INFORMATION SERVICES.--The Council shall coordinate the activities of appropriate agencies and departments to promote the development of information services that could be provided over the Network. These services shall include the provision of directories of users and services on computer networks, data bases of unclassified Federal scientific data, training of users of data bases and networks, access to commercial information services for users of the Network, and technology to support computer-based collaboration that allows researchers around the Nation to share information and instrumentation.

(h) USE OF GRANT FUNDS.--The National Science Foundation, the National Aeronautics and Space Administration, the Department of Energy, the Department of Defense, the Department of Commerce, the Department of the Interior, the Department of Agriculture, the Department of Health and Human Services, and the Environmental Protection Agency may allow recipients of Federal research grants to use grant funds to pay for computer networking expenses.

(i) REPORT.--Within 1 year after the date of enactment of this Act, the Director, through the Council, shall report to the Congress on--

(1) effective mechanisms for providing operating funds for the maintenance and use of the Network, including user fees, industry support, and continued Federal investment;

(2) plans for the eventual commercialization of the Network;

(3) how commercial information service providers could be charged for access to the Network;

(4) the technological feasibility of allowing commercial information service providers to use the

Network and other federally funded research networks;

(5) how Network users could be charged for such commercial information services;

(6) how to protect the copyrights of material distributed over the Network; and

(7) appropriate policies and standards to ensure the security of resources available on the Network and to protect the privacy of users of networks.

SEC. 7. ROLE OF THE NATIONAL SCIENCE FOUNDATION.

(a) GENERAL RESPONSIBILITIES.--In accordance with the Plan developed under section 5, the National Science Foundation shall provide computing and networking infrastructure support for all science and engineering disciplines, and develop enabling technologies for advanced computing and communications.

(b) COORDINATING RESPONSIBILITIES.--In addition to coordinating responsibilities for the Network specified in section 6, the National Science Foundation shall coordinate activities under the Plan developed under section 5 in basic research and human resource development.

(c) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the National Science Foundation for the purposes of this Act $213,000,000 for fiscal year 1992; $262,000,000 for fiscal year 1993; $305,000,000 for fiscal year 1994; $354,000,000 for fiscal year 1995; and $413,000,000 for fiscal year 1996.

SEC. 8. ROLE OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

(a) GENERAL RESPONSIBILITIES.--In accordance with the Plan developed under section 5, the National Aeronautics and Space Administration shall conduct basic and applied research in high-performance computing, particularly in the fields of computational aerosciences, earth and space sciences, and remote exploration and experimentation.

(b) COORDINATING RESPONSIBILITIES.--The National Aeronautics and Space Administration shall coordinate activities under the Plan developed under section 5 involving the accumulation of and access to the high-performance computing software, and, together with the Department of Energy, shall coordinate activities under such Plan in high-performance computing system development, evaluation, and applications software capabilities.

(c) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the National Aeronautics and Space Administration for the purposes of this Act $72,000,000 for fiscal year 1992; $107,000,000 for fiscal year 1993; $134,000,000 for fiscal year 1994; $151,000,000 for fiscal year 1995; and $145,000,000 for fiscal year 1996.

SEC. 9. ROLE OF THE DEPARTMENT OF ENERGY.

(a) GENERAL RESPONSIBILITIES.--In accordance with the Plan developed under section 5, the Department of Energy shall--

(1) perform technology development and systems evaluation of high-performance computing systems;

(2) conduct computational research with emphasis on energy applications;

(3) conduct gigabit network applications research and develop related software tools; and

(4) support basic research in computational science.

(b) COORDINATING RESPONSIBILITIES.--The Department of Energy, together with the National Aeronautics and Space Administration, shall coordinate activities under the Plan developed under section 5 in high-performance computing system development, evaluation, and applications software capabilities.

(c) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the Department of Energy for the purposes of this Act $93,000,000 for fiscal year 1992; $110,000,000 for fiscal year 1993; $138,000,000 for fiscal year 1994; $157,000,000 for fiscal year 1995; and $168,000,000 for fiscal year 1996.

SEC. 10. ROLE OF THE DEPARTMENT OF COMMERCE.

(a) GENERAL RESPONSIBILITIES.--In accordance with the Plan developed under section 5--

(1) the National Institute of Standards and Technology shall adopt standards and guidelines, and develop measurement techniques and test methods, for the interoperability of high-performance computers in networks and for common user interfaces to systems, and shall be responsible for developing benchmark tests and standards for high-performance computers and software; and

(2) the National Oceanic and Atmospheric Administration shall conduct basic and applied research in weather prediction and ocean sciences, particularly in development of new forecast models, in computational fluid dynamics, and in the incorporation of evolving computer architectures and networks into the systems that carry out agency missions.

(b) COORDINATING RESPONSIBILITIES.--The National Institute of Standards and Technology shall coordinate activities under the Plan developed under section 5 in high-performance computing system instrumentation, evaluation, and standards.

(c) HIGH-PERFORMANCE COMPUTING AND NETWORK SECURITY.--The National Institute of Standards and Technology shall conduct research needed to support the adoption of security standards for high-performance computer systems and networks. In accomplishing this objective, the National Institute of Standards and Technology shall utilize whenever possible recognized centers of expertise that may exist in the academic and national laboratory communities.

(d) STUDY OF IMPACT OF REGULATIONS.--(1) The Secretary of Commerce shall conduct a study to evaluate the impact of Federal procurement regulations which require that contractors providing software to the Federal Government share the rights to proprietary software development tools that the contractors use to develop the software, including a determination of whether such regulations discourage development of improved software development tools and techniques.

(2) The Secretary of Commerce shall, within 1 year after the date of enactment of this Act, report to the Congress regarding the results of the study conducted under paragraph (1).

(e) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated--

(1) to the National Institute of Standards and Technology for the purposes of this Act $3,000,000 for fiscal year 1992; $3,500,000 for fiscal year 1993; $4,000,000 for fiscal year 1994; $4,500,000 for fiscal

year 1995; and $5,000,000 for fiscal year 1996.

(2) to the National Oceanic and Atmospheric Administration for the purposes of this Act $2,500,000 for fiscal year 1992; $3,000,000 for fiscal year 1993; $3,500,000 for fiscal year 1994; $4,000,000 for fiscal year 1995; and $4,500,000 for fiscal year 1996..

SEC. 11. ROLE OF THE ENVIRONMENTAL PROTECTION AGENCY.

(a) GENERAL RESPONSIBILITIES.--In accordance with the Plan developed under section 5, the Environmental Protection Agency shall conduct basic and applied research directed toward the advancement and dissemination of computational techniques and software tools which form the core of ecosystem, atmospheric chemistry, and atmospheric dynamics models.

(b) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the Environmental Protection Agency for the purposes of this Act $5,000,000 for fiscal year 1992; $5,500,000 for fiscal year 1993; $6,000,000 for fiscal year 1994; $6,500,000 for fiscal year 1995; and $7,000,000 for fiscal year 1996.

Mr. Boucher. In developing the substitute, we have worked very closely with the Subcommittee on Technology and Competitiveness of the full committee, which had a joint referral of H.R. 656, and with the Republican leadership of this subcommittee and the other subcommittee, and with the ranking Republican member of the full committee.

The substitute incorporates all of the amendments to H.R. 656 that were approved by the Technology and Competitiveness Subcommittee at its markup on April 10. The changes that this subcommittee is proposing have been reviewed at the staff level with the Technology Subcommittee and with the minority of both subcommittees, and we understand that those proposed changes are acceptable.

I want to recognize the efforts of Mr. Packard, the gentleman from California, the ranking minority member of this subcommittee, for his assistance in moving the legislation forward, and to thank him for his help.

I also want to thank Mr. Valentine and Mr. Lewis, the chairman and ranking Republican member, respectively, of the Technology and Competitiveness Subcommittee, for their cooperation in arriving at this consensus amendment.

The purpose of the legislation is to provide a focused and coordinated Federal research program in high performance computing. It will advance research and development activities in universities, in Federal laboratories, and with private industry. It will also improve education at all levels.

Funding is authorized for the development and use of new supercomputers, advanced software, and a national research and education network capable of transmitting billions of bits of data per second. We are also seeking to expand the human resource base in computer and computational sciences.

Responsibility for coordination and planning for the program is assigned to the Office of Science and Technology Policy through the Federal Coordinating Council for Engineering, Science, and Technologies. The roles and responsibilities assigned to specific agencies for different areas of the program are consistent with the plan for High Performance Computing and Communications which accompanied the President's fiscal year 1992 budget request.

The amendment authorizes a total of $1.55 billion for the National Science Foundation, $609 million, for NASA, $666 million for the Department of Energy, $38 million for the Department of Commerce, and $30 million for the Environmental Protection Agency for the years 1992 through 1996. These authorizations are from sums otherwise authorized to the agencies through the usual authorization process. Each agency participating in the program is required by the legislation to include a specific funding request for the program in its annual budget submission.

The substitute incorporates suggestions from OSTP to ensure greater conformity between the program authorized and the program that was proposed in the President's fiscal year 1992 budget submission to simplify reporting requirements and to clarify a number of specific provisions.

In addition, we have carefully reviewed the comments of our witnesses at the March 7 joint hearing between this subcommittee and the Subcommittee on Technology and Competitiveness in developing the substitute. Provisions have been included to ensure close collaboration between OSTP and many parts of the private sector which will be involved as R&D performers, as suppliers of services, and as users of the network.

Through the enactment of this legislation, we have an excellent opportunity to ensure scientific and technological progress in fields that are of enormous importance to the future well-being of the American society.

It is my pleasure to commend the substitute to this subcommittee for its consideration.

The chair is now pleased to recognize the ranking minority member of this subcommittee, Mr. Packard from California.

Mr. **Packard**. Thank you, Mr. Chairman.

The high performance computing bill, as a cooperative interagency initiative, encompasses the leading edge of computer technologies. It is a program that calls for the various agencies to provide a support function to universities, the supercomputer centers, national laboratories, and private industry in developing this network.

The majority staff of the subcommittee has been very helpful in addressing my concerns about this initiative—specifically, that it is to be a commercial venture from the very beginning. I know the administration may still have some concerns about the bill, and I will be happy to work with the administration in the future on these or other concerns.

At this time, I do support the initiative, because the amounts authorized for the various agencies are in line with the administration's budget request for fiscal year 1992.

Again, I want to thank you, Mr. Chairman, and the staff on both the majority and minority side, in working out this particular piece of legislation and the one that we have just passed.

Thank you.

Mr. **Boucher**. The chair thanks the gentleman and again expresses appreciation for the gentleman's excellent assistance and that of his staff in preparing this substitute.

I now ask unanimous consent that the amendment in the nature of a substitute be considered as original text for purposes of the markup. Hearing no objection, it is so ordered.

The amendment will, without objection, be considered as read and is now open for amendment at any point.

Mr. **Packard**. Mr. Chairman, I am not aware of any amendments on our side of the aisle.

Mr. **Boucher**. Are there other Members who seek recognition for the purpose of offering amendments?

The gentleman from Arkansas.

Mr. **Thornton**. Mr. Chairman, I would like to move that the substitute be adopted.

Mr. **Boucher**. The chair thanks the gentleman.

The motion is that the amendment in the nature of a substitute be adopted. Is there discussion on the motion?

The chair will put the question. Those in favor will say "aye."

[Chorus of ayes.]

Mr. **Boucher**. Those opposed, "no."

[No response.]

Mr. **Boucher**. The ayes have it, and the amendment in the nature of a substitute is adopted.

The chair recognizes the gentleman from California.

Mr. **Packard**. Mr. Chairman, I would move that the subcommittee report the bill, as amended, and, furthermore, I move to instruct the staff to prepare the subcommittee report and to make the necessary technical and conforming changes, and that the chairman take all necessary steps to bring the bill before the full committee for consideration.

Mr. **Boucher**. The question is on the motion of the gentleman from California, Mr. Packard. Those in favor will say "aye."

[Chorus of ayes.]

Mr. **Boucher**. Those opposed, "no."

[No response.]

Mr. **Boucher**. The ayes have it, and the motion is agreed to, and the bill, as amended, is reported.

The chair would advise the Members that those desiring to cosponsor the legislation will have an opportunity to do so between now and—shall we propose a date?—next Tuesday, April 23—between now and noon on April 23, which, coincidentally, is the same length of time available for cosponsoring the first bill reported by the subcommittee this morning.

There being no further business to come before the subcommittee at this time—

Mr. **Packard**. Mr. Chairman, I want to congratulate you on the efficiency of the dispatching of these issues.

Mr. **Boucher**. Thank you very much, Mr. Packard.

The subcommittee stands adjourned.

[Whereupon, at 9:58 a.m., the subcommittee was adjourned.]

FULL COMMITTEE MARKUP OF H.R. 656, THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

WEDNESDAY, MAY 8, 1991

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The committee met, pursuant to notice, at 10:00 a.m. in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. [chairman of the committee] presiding.

Mr. BROWN. At this point, I will move to take up the High Performance Computing Act of 1991, H.R. 656, which was introduced in January and is designed to improve coordination and expand support by Federal agencies for R&D of high performance computing. The bill will accelerate the development of what has become an indispensable tool in science and engineering research. Moreover, the potential economic importance of high performance computing is becoming increasing evident and so forth, and so forth. Without objection, the rest of my statement will be put in the record.

[The prepared statement of Mr. Brown, plus A copy of H.R. 656 follow:]

STATEMENT OF THE HONORABLE GEORGE E. BROWN, JR., (D-CA) CHAIRMAN, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY ON MARKUP OF H.R. 656, THE HIGH-PERFORMANCE COMPUTING ACT OF 1991

MAY 8, 1991

H.R. 656, WHICH I INTRODUCED IN JANUARY, IS DESIGNED TO IMPROVE COORDINATION AND EXPAND SUPPORT BY FEDERAL AGENCIES FOR RESEARCH AND DEVELOPMENT OF HIGH-PERFORMANCE COMPUTING. THIS BILL WILL ACCELERATE THE DEVELOPMENT OF WHAT HAS BECOME AN INDISPENSABLE TOOL IN SCIENCE AND ENGINEERING RESEARCH. MOREOVER, THE POTENTIAL ECONOMIC IMPORTANCE OF HIGH-PERFORMANCE COMPUTING IS BECOMING INCREASINGLY EVIDENT IN MANY APPLICATIONS ARISING IN THE MANUFACTURING AND THE SERVICE SECTORS OF THE ECONOMY.

THE MARCH 1991 REPORT OF THE NATIONAL CRITICAL TECHNOLOGIES PANEL IDENTIFIES 22 CRITICAL TECHNOLOGIES, OF WHICH 7 FALL WITHIN THE BROAD AREA OF INFORMATION SCIENCE AND COMMUNICATIONS. KEY ENABLING TECHNOLOGIES LISTED IN THIS PORTION OF THE REPORT INCLUDE HIGH-PERFORMANCE COMPUTING AND NETWORKING, SOFTWARE DEVELOPMENT, DATA STORAGE AND PERIPHERALS, AND COMPUTER SIMULATION AND MODELING. H.R. 656 PROVIDES FOR A COORDINATED FEDERAL PROGRAM WHICH WILL ADDRESS ALL OF THESE TECHNOLOGIES.

H.R. 656 PROVIDES AN OPPORTUNITY TO MAINTAIN UNITED STATES LEADERSHIP IN AREAS WHICH ARE IMPORTANT FOR THE LONG-TERM WELL-BEING OF THE NATION. HIGH-PERFORMANCE COMPUTING WILL BOTH ENHANCE ECONOMIC COMPETITIVENESS AND PROVIDE A RESOURCE TO STIMULATE THE CREATIVE IMAGINATIONS OF THE NATION'S SCIENTISTS AND ENGINEERS.

IN HIS MARCH 6 SPEECH TO CONGRESS, THE PRESIDENT CHALLENGED US TO PASS ENABLING LEGISLATION TO RESTORE AMERICA'S ECONOMIC LEADERSHIP WITHIN 100 DAYS. THE NEXT DAY AT THE JOINT SUBCOMMITTEE HEARING ON H.R. 656, I SUGGESTED THAT THE HIGH-PERFORMANCE COMPUTING PROGRAM SHOULD BE INCLUDED IN THE PRESIDENT'S CHALLENGE, AND I ASKED THE COMMITTEE TO MOVE THE BILL IN ORDER TO MEET THAT DEADLINE.

I AM VERY PLEASED THAT MR. BOUCHER AND MR. VALENTINE, THE CHAIRMEN OF THE SUBCOMMITTEE ON SCIENCE AND THE SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS, RESPECTIVELY, HAVE ACTED WITH SUCH DISPATCH IN MOVING AND PERFECTING THIS LEGISLATION. I ALSO WANT TO THANK MR. PACKARD AND MR. LEWIS, THE CORRESPONDING RANKING REPUBLICAN MEMBERS OF THE TWO SUBCOMMITTEES, BECAUSE I REALIZE THAT THIS HAS BEEN A BIPARTISAN EFFORT.

102d CONGRESS
1st Session

H. R. 656

To provide for a coordinated Federal research program to ensure continued United States leadership in high-performance computing.

IN THE HOUSE OF REPRESENTATIVES

January 28, 1991

Mr. Brown of California (for himself, Mr. Valentine, Mr. Boehlert, Mr. Mineta, and Mr. Browder) introduced the following bill; which was referred to the Committee on Science, Space, and Technology

---

A BILL

To provide for a coordinated Federal research program to ensure continued United States leadership in high-performance computing.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "High-Performance Computing Act of 1991".

SEC. 2. FINDINGS AND PURPOSE.

(a) Findings.—The Congress finds the following:

(1) Advances in computer science and technology are vital to the Nation's prosperity, national and economic security, and scientific advancement.

(2) The United States currently leads the world in the development and use of high-performance computing for national security, industrial productivity, and science and engineering, but that lead is being challenged by foreign competitors.

(3) Further research, improved computer research networks, and more effective technology transfer from government to industry are necessary for the United States to fully reap the benefits of high-performance computing.

(4) Several Federal agencies have ongoing high-performance computing programs, but improved interagency coordination, cooperation, and planning could enhance the effectiveness of these programs.

(5) A 1989 report by the Office of Science and Technology Policy outlining a research and development strategy for high-performance computing provides a framework for a multiagency high-performance computing program.

(b) PURPOSE.—It is the purpose of Congress in this Act to help ensure the continued leadership of the United States in high-performance computing and its applications through—

(1) the expansion of Federal support for research, development, and application of high-performance computing in order to—

(A) establish a high-capacity national research and education computer network;

(B) expand the number of researchers, educators, and students with training in high-performance computing and access to high-performance computing resources;

(C) develop an information infrastructure of data bases, services, access mechanisms, and research facilities which is available for use through such a national network;

(D) stimulate research on software technology;

(E) promote the more rapid development and wider distribution of computer software tools and applications software;

(F) accelerate the development of computer systems and subsystems;

(G) provide for the application of high-performance computing to Grand Challenges; and

(II) invest in basic research and education; and

(2) the improvement of planning and coordination of Federal research and development on high-performance computing.

SEC. 3. DEFINITIONS.

As used in this Act, the term—

(1) "Council" means the Federal Coordinating Council for Science, Engineering, and Technology;

(2) "Director" means the Director of the Office of Science and Technology Policy; and

(3) "Grand Challenge" means a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

SEC. 4. MISCELLANEOUS PROVISIONS.

(a) NONAPPLICABILITY.—Except to the extent the appropriate Federal agency or department head determines, the provisions of this Act shall not apply to—

(1) programs or activities regarding computer systems that process classified information; or

(2) computer systems the function, operation, or use of which are those delineated in paragraphs (1) through (5) of section 2315(a) of title 10, United States Code.

(b) ACQUISITION OF PROTOTYPE AND EARLY PRODUCTION MODELS.—Where appropriate, and in accordance with Federal contracting law, Federal agencies and departments shall procure prototype or early production models of new high-performance computer systems and subsystems to stimulate hardware and software development.

SEC. 5. NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM.

The National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq.) is amended by adding at the end the following new title:

"TITLE VII—NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM

"NATIONAL HIGH-PERFORMANCE COMPUTING PLAN

"SEC. 701. (a)(1) The President, through the Federal Coordinating Council for Science, Engineering, and Technology (hereafter in this title referred to as the 'Council'), shall, in accordance with the provisions of this title—

"(A) develop and implement a National High-Performance Computing Plan (hereafter in this title referred to as the 'Plan'); and

"(B) provide for interagency coordination of the implementation of the Plan.

The Plan shall contain recommendations for a 5-year national effort and shall be submitted to the Congress within 1 year after the date of enactment of this title. The Plan shall be resubmitted upon revision at least once every 2 years thereafter.

"(2) The Plan shall—

"(A) establish the goals and priorities for a Federal high-performance computing program for the fiscal year in which the Plan (or revised Plan) is submitted and the succeeding 4 fiscal years;

"(B) set forth the role of each Federal agency and department in implementing the Plan; and

"(C) describe the levels of Federal funding for each agency and department and specific activities, including education, research activities, hardware and software development, establishment of a national multi-gigabit-per-second research and education computer network, to be known as the National Research and Education Network, and acquisition and operating expenses for computers and computer networks, required to achieve the goals and priorities established under subparagraph (A).

"(3) The Plan shall address, where appropriate, the relevant programs and activities of—

"(A) the National Science Foundation;

"(B) the Department of Commerce, particularly the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Telecommunications and Information *Administration;*

"(C) the National Aeronautics and Space Administration;

"(D) the Department of Defense, particularly the Defense Advanced Research Projects Agency;

"(E) the Department of Energy;

"(F) the Department of Health and Human Services, particularly the National Institutes of Health and the National Library of Medicine;

"(G) the Department of Education;

"(H) the Department of Agriculture, particularly the National Agricultural Library; and

"(I) such other agencies and departments as the President or the Chairman of the Council considers appropriate.

"(4) In addition, the Plan shall take into consideration the present and planned activities of the Library of Congress, as the Librarian of Congress considers appropriate.

"(5) The Plan shall identify how agencies and departments can collaborate to—

"(A) ensure interoperability among computer networks run by the agencies and departments;

"(B) increase software productivity, capability, portability, and reliability;

"(C) expand efforts to improve, document, and evaluate unclassified public-domain software developed by federally funded researchers and other software, including federally funded educational and training software;

"(D) cooperate, where appropriate, with industry in the development and exchange of software;

"(E) distribute software among the agencies and departments;

"(F) distribute federally funded software to State and local governments, industry, and universities;

"(G) accelerate the development of high-performance computer systems, subsystems, and associated software;

"(H) provide the technical support and research and development of high-performance computer software and hardware needed to address Grand Challenges in astrophysics, geophysics, engineering, materials, biochemistry, plasma physics, weather and climate forecasting, and other fields;

"(I) provide for educating and training additional undergraduate and graduate students in software engineering, computer science, and computational science; and

"(J) identify agency and department rules, regulations, policies, and practices which can be changed to significantly improve utilization of Federal high-performance computing and network facilities, and make recommendations to such agencies and departments for appropriate changes.

"(6) The Plan shall address the security requirements and policies necessary to protect Federal research computer networks and information resources accessible through Federal research computer networks. Agencies and departments identified in the Plan shall define and implement a security plan consistent with the Plan.

"(b) The Council shall—

"(1) serve as lead entity responsible for development of the Plan and interagency coordination of the implementation of the Plan;

"(2) coordinate the high-performance computing research and development activities of Federal agencies and departments and report at least annually to the President, through the Chairman of the Council, on any recommended changes in agency or departmental roles that are needed to better implement the Plan;

"(3) review, prior to the President's submission to the Congress of the annual budget estimate, each agency and departmental budget estimate in the context of the Plan and make the results of that review available to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget; and

"(4) consult and coordinate with Federal agencies and departments, and academic, State, industry, and other appropriate groups conducting research on high-performance computing.

"(c) The Director of the Office of Science and Technology Policy shall establish a High-Performance Computing Advisory Panel consisting of prominent representatives from industry and academia who are specially qualified to provide the Council with advice and information on high-performance computing. The Panel shall provide the Council with an independent assessment of—

"(1) progress made in implementing the Plan;

"(2) the need to revise the Plan;

"(3) the balance between the components of the Plan;

"(4) whether the research and development funded under the Plan is helping to maintain United States leadership in computing technology; and

"(5) other issues identified by the Director.

"(d)(1) Each appropriate Federal agency and department involved in high-performance computing shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report to the Office identifying each element of its high-performance computing activities, which—

"(A) specifies whether each such element (i) contributes primarily to the implementation of the Plan, or (ii) contributes primarily to the achievement of other objectives but aids Plan implementation in important ways; and

"(B) states the portion of its request for appropriations that is allocated to each such element.

"(2) The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency and departmental responsibilities set forth in the Plan, and shall include, in the President's annual budget estimate, a statement of the portion of each appropriate agency or department's annual budget estimate that is allocated to each element of such agency or department's high-performance computing activities.

"(e) As used in this section, the term 'Grand Challenge' means a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

"ANNUAL REPORT

"SEC. 702. The Chairman of the Council shall prepare and submit to the President and the Congress, not later than March 1 of each year, a report on the activities conducted pursuant to this title during the preceding fiscal year, including—

"(1) a summary of the achievements of Federal high-performance computing research and development efforts during that preceding fiscal year;

"(2) an analysis of the progress made toward achieving the goals and priorities of the Plan;

"(3) a copy and summary of the Plan and any changes made in such Plan;

"(4) a summary of appropriate agency and departmental budgets for high-performance computing activities for that preceding fiscal year; and

"(5) any recommendations regarding additional action or legislation which may be required to assist in carrying out this title.".

SEC. 6. NATIONAL RESEARCH AND EDUCATION NETWORK.

(a) ESTABLISHMENT.—In accordance with the Plan developed under section 701 of the National Science and Technology Policy, Organization, and Priorities Act of 1976, as added by section 5 of this Act, the National Science Foundation, in cooperation with the Department of Defense, the Department of Energy, the Department of Commerce, the National Aeronautics and Space Administration, and other appropriate agencies, shall provide for the establishment of a national multi-gigabit-per-second research and education computer network by 1996, to be known as the National Research and Education Network (hereafter in this Act referred to as the "Network"), which shall link government, industry, and the education community.

(b) ACCESS.—The Network shall provide users with appropriate access to high-performance computers, computer data bases, other research facilities, and libraries.

(c) NETWORK CHARACTERISTICS.—The Network shall—

(1) be developed in close cooperation with the computer, telecommunications, and information industries;

(2) be designed and developed with the advice of potential users in government, industry, and the higher education community;

(3) be established in a manner which fosters and maintains competition and private sector investment in high speed data networking within the telecommunications industry;

(4) be established in a manner which promotes research and development leading to deployment of commercial data communications and telecommunications standards;

(5) be designed to ensure the continued application of laws that protect copyright and intellectual property rights or that control access to data bases;

(6) where technically feasible, have accounting mechanisms which allow, where appropriate, users or groups of users to be charged for their usage of the Network and copyrighted materials available over the Network; and

(7) be phased into commercial operation as commercial networks can meet the networking needs of American researchers and educators.

(d) DEPARTMENT OF DEFENSE RESPONSIBILITY.—The Department of Defense, through the Defense Advanced Research Projects Agency, shall be lead agency for research and development of advanced fiber optics technology, switches, and protocols needed to develop the Network.

(e) NATIONAL SCIENCE FOUNDATION RESPONSIBILITY.—Within the Federal Government, the National Science Foundation shall have primary responsibility for connecting colleges, universities, and libraries to the Network.

(f) ROLE OF THE COUNCIL.—(1) The Council, within 1 year after the date of enactment of this Act and consistent with the Plan developed under section 701 of the National Science and Technology Policy, Organization, and Priorities Act of 1976, as added by section 5 of this Act, shall—

(A) develop goals, strategy, and priorities for the Network;

(B) identify the roles of Federal agencies and departments implementing the Network;

(C) provide a mechanism to coordinate the activities of Federal agencies and departments in deploying the Network;

(D) oversee the operation and evolution of the Network;

(E) manage the connections between computer networks of Federal agencies and departments;

(F) develop conditions for access to the Network; and

(G) identify how existing and future computer networks of Federal agencies and departments could contribute to the Network.

(2) The President shall report to Congress within 1 year after the date of enactment of this Act on the implementation of this subsection.

(g) USE OF GRANT FUNDS.—The National Science Foundation, the National Aeronautics and Space Administration, the Department of Energy, the Department of Defense, the Department of Commerce, the Department of the Interior, the Department of Agriculture, the Department of Health and Human Services, and the Environmental Protection Agency may allow recipients of Federal research grants to use grant funds to pay for computer networking expenses.

(h) REPORT.—Within 1 year after the date of enactment of this Act, the Director, through the Council, shall report to the Congress on—

(1) effective mechanisms for providing operating funds for the maintenance and use of the Network, including user fees, industry support, and continued Federal investment;

(2) plans for the eventual commercialization of the Network;

(3) how commercial information service providers could be charged for access to the Network;

(4) the technological feasibility of allowing commercial information service providers to use the Network and other federally funded research networks;

(5) how Network users could be charged for such commercial information services;

(6) how to protect the copyrights of material distributed over the Network; and

(7) appropriate policies to ensure the security of resources available on the Network and to protect the privacy of users of networks.

SEC. 7. ROLE OF THE NATIONAL SCIENCE FOUNDATION.

(a) GENERAL RESPONSIBILITIES.—The National Science Foundation shall provide funding to enable researchers to access high-performance computers. Prior to deployment of the Network, the National Science Foundation shall maintain, expand, and upgrade its existing computer networks. The responsibilities of the National Science Foundation may include promoting development of information services and data bases available over such computer networks; facilitation of the documentation, evaluation, and distribution of research software over such computer networks; encouragement of continued development of innovative software by industry; and promotion of science and engineering education.

(b) INFORMATION SERVICES.—The National Science Foundation shall, in cooperation with other appropriate agencies and departments, promote the development of information services that could be provided over the Network established under section 6. These services shall include the provision of directories of users and services on computer networks, data bases of unclassified Federal scientific data, training of users of data bases and networks, access to commercial information services to users of the Network, and technology to support computer-based collaboration that allows researchers around the Nation to share information and instrumentation.

(c) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the National Science Foundation for the purposes of this Act $46,000,000 for fiscal year 1992, of which $15,000,000 shall be for purposes of section 6; $88,000,000 for fiscal year 1993, of which $25,000,000 shall be for purposes of section 6; $145,000,000 for fiscal year 1994, of which $55,000,000 shall be for purposes of section 6; $172,000,000 for fiscal year 1995, of which $50,000,000 shall be for purposes of section 6; and $199,000,000 for fiscal year 1996, of which $50,000,000 shall be for purposes of section 6.

SEC. 8. ROLE OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

(a) GENERAL RESPONSIBILITIES.—In accordance with the Plan developed under section 701 of the National Science and Technology Policy, Organization, and Priorities Act of 1976, as added by section 5 of this Act, the National Aeronautics and Space Administration shall conduct basic and applied research in high-performance computing, particularly in the field of computational science, with emphasis on aeronautics and the processing of remote sensing and space science data.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the National Aeronautics and Space Administration for the purposes of this Act $22,000,000 for fiscal year 1992, $45,000,000 for fiscal year 1993, $67,000,000 for fiscal year 1994, $89,000,000 for fiscal year 1995, and $115,000,000 for fiscal year 1996.

SEC. 9. ROLE OF THE DEPARTMENT OF COMMERCE.

(a) GENERAL RESPONSIBILITIES.—The National Institute of Standards and Technology shall adopt standards and guidelines, and develop measurement techniques and test methods, for the interoperability of high-performance computers in networks and for common user interfaces to systems. In addition, the National Institute of Standards and Technology shall be responsible for developing benchmark tests and standards for high-performance computers and software.

(b) STUDY OF IMPACT OF REGULATIONS.—(1) The Secretary of Commerce shall conduct a study to evaluate the impact of Federal procurement regulations which require that contractors providing software to the Federal Government share the rights to proprietary software development tools that the contractors use to develop the software, including a determination of whether such regulations discourage development of improved software development tools and techniques.

(2) The Secretary of Commerce shall, within 1 year after the date of enactment of this Act, report to the Congress regarding the results of the study conducted under paragraph (1).

○

Mr. **Brown**. I want to commend the two subcommittees that worked on this, headed by Mr. Boucher and Mr. Valentine, and the respective ranking members, Mr. Packard and Mr. Lewis. I would point out that this bill has the active support of the Administration and the subcommittees have worked diligently to make sure the language which we have before us is acceptable to the Administration. We are assured that that is the case.

The Chair would now like to recognize Mr. Walker for any comments he might have with regard to this legislation.

Mr. **Walker**. Thank you, Mr. Chairman.

The bill, with the substitute amendment before the committee today, is a good piece of legislation. I am confident it is one that can be supported by all the members. This is something where we have worked out some of the concerns the Administration had and the legislation will provide for implementation of the high performance computing initiatives submitted by the President to the Congress in February.

Mr. Chairman, I appreciate your cooperation and that of the subcommittees and the staffs in working out the details of the substitute amendment. I believe we have addressed most of the Administration's concerns, especially the proper language that gives the Executive Branch discretion over the management of the program. I understand there may be a couple of outstanding issues, including the role of the National Science Foundation as a management agency in the network initiative, and further clarification to the responsibility for program implementation. I look forward to resolving these issues as we move forward in the process. In the meantime, I plan to add my name as a co-sponsor of the bill after the markup today. I would ask unanimous consent that some additional remarks I have prepared here be included in the record.

[The prepared statement of Mr. Walker follows:]

OPENING STATEMENT
of the Honorable Robert S. Walker
H.R. 656 - High-Performance Computing Act

The substitute amendment before the Committee today is a good piece of legislation, and one which I am confident can be supported by all Members.

This legislation provides for the implementation of the High Performance Computing Initiative submitted by the President to Congress in February. It provides for federal involvement in the research and development of high performance computing systems and software, and provides for federal support of the deployment of a gigabit per second research and education network. There are a number of federal departments and agencies whose missions will be enhanced by the existence of such a network, and which in turn can provide unique assistance in deploying it.

But, this legislation makes very clear that the network is to be a commercial network right from the beginning. It is to be developed jointly with the computer, telecommunications, and information industries, and it is to be designed in such a way that encourages the establishment of privately-operated high-speed commercial networks. Above all, the federal government will not be purchasing switches, optical fiber, or other hardware, except that which is needed for research and development.

(more)

I am also pleased that the five-year authorizations for the agencies under this Committee's jurisdiction are within the Administration's projections. The sums authorized are to come from the overall amounts authorized for each agency. In this way, the High Performance Computing Initiative will viewed as an integral part of each agency's budget. By authorizing this Initiative for five years, we should be able to maintain better control over the costs of the program.

Mr. Chairman, I appreciate your cooperation and that of your staff in working out the details of the substitute amendment. I believe that we have addressed most of the Administration's concerns, especially the proper maintenance Executive Branch discretion over the management of the program. I understand that there may be a couple of outstanding issues, including the role of the National Science Foundation as the management agency in the network initiative, and further clarification of the responsibility for program implementation. I look forward to resolving these issues as we move forward in the process. In the meantime, I plan to add my name as a cosponsor of this bill after markup today.

Mr. Brown. Without objection, so ordered.

The Chair would like to recognize first Mr. Valentine, then Mr. Lewis, then Mr. Boucher, and then Mr. Packard for their comments.

I might say that this is conceivably amongst the most important pieces of legislation that this committee will consider this year, and possibly that the Congress will consider, and it is worth a word or two from each of the people who were so intimately involved.

Mr. Valentine. Mr. Chairman, in keeping with the spirit of the occasion, I will not undertake to read into these record the seven pages containing pearls of wisdom. I do that with confident belief that the members of the full committee will take the time to read my remarks, as in the record, and if they will do that, initial them and send them to me, I would appreciate it.

[Laughter.]

Mr. Valentine. Suffice it to say, it has been a pleasure for our committee on Technology and Competitiveness, for us to work with our friend and distinguished member from Virginia, Rick Boucher, Chairman of the Subcommittee on Science, and with Ron Packard, the ranking member of the Science Subcommittee and of course with our good friend Tom Lewis from Florida, the ranking member of our Subcommittee on Technology and Competitiveness.

As the Chairman has pointed out, this is a meaningful advancement for our Nation, and legislation which I think deserves bipartisan support, not only of this committee but of the entire House of Representatives. With that I ask unanimous consent to submit my statement for the record.

[The prepared statement of Mr. Valentine follows:]

STATEMENT BY THE HON. TIM VALENTINE (D-NC)
FULL COMMITTEE MARK UP OF H.R. 656

MR. CHAIRMAN, THE ADVANCEMENT OF AMERICA'S TECHNOLOGICAL INTERESTS IS CRUCIAL TO OUR WELL-BEING. HIGH PERFORMANCE COMPUTING IS A VITAL TECHNOLOGY GREATLY AFFECTING SCIENTIFIC, EDUCATIONAL, AND ECONOMIC COMPETITIVE INTERESTS. THEREFORE, HIGH PERFORMANCE COMPUTING IS EXTREMELY IMPORTANT TO BOTH THE SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS AND TO THE SUBCOMMITTEE ON SCIENCE.

THE 1990s WILL BE MARKED BY THE CONTINUED RAPID ADVANCEMENT OF HIGH PERFORMANCE COMPUTING TECHNOLOGIES. WHILE THE U.S. IS STILL REGARDED AS THE WORLD'S LEADER IN THIS FIELD, WE ARE BEING CHALLENGED BY FOREIGN COMPETITORS.

OUR NATION MUST CONTINUE TO LEAD THE WAY IN THE EXPLOITATION AND DEVELOPMENT OF HIGH PERFORMANCE COMPUTING SYSTEMS. WE MUST CONTINUE TO LEAD THE WAY IN DEVELOPING AND INTEGRATING ADVANCED NETWORKS FOR SUPPORTING REMOTE VISUALIZATION, INTERACTIVE COMMUNICATIONS, COLLABORATIVE COMPUTING OVER DISTRIBUTED RESOURCES, AND EFFICIENT TRANSFER OF ENORMOUS VOLUMES OF DATA.

THE COMMITTEE PRINT BEFORE YOU - AN AMENDMENT IN THE NATURE OF A SUBSTITUTE TO H.R.656, WHICH WAS ORIGINALLY INTRODUCED BY CHAIRMAN BROWN - AUTHORIZES THE HIGH PERFORMANCE COMPUTING ACT OF 1991. THE HIGH PERFORMANCE ACT OF 1991 IS A FIVE-YEAR PROGRAM FOR RESEARCH AND DEVELOPMENT ON ADVANCED COMPUTER HARDWARE AND SOFTWARE TECHNOLOGIES AND ADVANCED COMPUTER NETWORKS.

THIS PROGRAM WILL PROMOTE CONTINUED RESEARCH AND DEVELOPMENT OF HIGH PERFORMANCE COMPUTING HARDWARE AND SOFTWARE TECHNOLOGIES. IT WILL TRANSFORM OUR CURRENT SCIENTIFIC COMPUTING NETWORKS INTO A HIGH CAPACITY NATIONAL RESEARCH AND EDUCATION NETWORK, THE NREN. ALSO, THIS PROGRAM WILL EXPAND THE NUMBER OF RESEARCHERS, EDUCATORS, STUDENTS, AND INDUSTRIAL USERS WITH TRAINING IN, AND ACCESS TO, HIGH PERFORMANCE COMPUTING.

THE AMOUNTS AUTHORIZED FOR FY 1992 REFLECT THE PRESIDENT'S REQUESTS FOR THE PARTICIPATING AGENCIES, AND THE OUT YEAR AUTHORIZATIONS ARE NUMBERS PROVIDED BY THE ADMINISTRATION.

THIS PROPOSED LEGISLATION IS THE RESULT OF COOPERATION ON MANY FRONTS. A JOINT HEARING ON H.R. 656 BEFORE THE SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS AND THE SUBCOMMITTEE ON SCIENCE WAS HELD ON MARCH 7, 1991. WITNESSES INCLUDED SEN. ALBERT GORE SPONSOR OF A COMPANION BILL IN THE SENATE; DR. D. ALLAN BROMLEY, DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY; AND REPRESENTATIVES FROM MANY AREAS AFFECTING AND AFFECTED BY HIGH PERFORMANCE COMPUTING COMPUTING.

AFTER CONTINUING COOPERATION BETWEEN THE TWO SUBCOMMITTEES, THE SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS MARKED UP AND REPORTED THE BILL ON APRIL 10, 1991. THE SUBCOMMITTEE ON SCIENCE USED THIS BILL AS THEIR MARK UP VEHICLE, AND ON APRIL 17, 1991, MARKED UP AND REPORTED THE BILL WITH ONLY MINOR CHANGES FROM THE TECHNOLOGY AND COMPETITIVENESS VERSION. BOTH SUBCOMMITTEES HAVE WORKED CLOSELY WITH THE ADMINISTRATION, THE PARTICIPATING DEPARTMENTS AND AGENCIES, AND MANY OTHERS IN DRAFTING THIS LEGISLATION.

IN MY OPENING STATEMENT AT THE TECHNOLOGY AND COMPETITIVENESS SUBCOMMITTEE MARK UP, I NOTED THAT THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY HAD ADDITIONAL CONCERNS WITH THE SUBCOMMITTEE VERSION OF H.R. 656. I ALSO INDICATED MY WILLINGNESS AND THAT OF OTHER COMMITTEE MEMBERS TO WORK OUT THESE DIFFERENCES. SUBSEQUENT CONVERSATIONS WITH OSTP REPRESENTATIVES AND AMONG THE COMMITTEE LEADERSHIP HAVE LED TO THE AMENDMENT IN THE NATURE OF A SUBSTITUTE BEING OFFERED TODAY ON BEHALF OF THE SUBCOMMITTEE CHAIRMEN AND RANKING REPUBLICANS AS WELL AS CHAIRMAN BROWN AND THE FULL COMMITTEE RANKING MEMBER MR. WALKER. THE AMENDMENT CONTAINS A NUMBER OF SIMPLIFICATIONS AND IMPROVEMENTS TO OUR SUBCOMMITTEES' REPORTED VERSION AND, THEREFORE, HAS MY WHOLE HEARTED SUPPORT.

THIS PROPOSED LEGISLATION WILL ENSURE THE CONTINUED COORDINATION AMONG GOVERNMENT, INDUSTRY, AND THE ACADEMIC COMMUNITY TO MAINTAIN AMERICA'S LEADERSHIP IN HIGH PERFORMANCE COMPUTING. HIGH PERFORMANCE COMPUTING CONTINUES TO CHANGE THE WAY SCIENCE IS DONE. TODAY'S GRAND CHALLENGES -- ECOLOGICAL, ENVIRONMENTAL, AGRICULTURAL, BIOMEDICAL, ENGINEERING -- ALL REQUIRE MORE POWERFUL COMPUTATIONAL TECHNOLOGY. THIS LEGISLATION IS NEEDED TO ASSURE THAT WE CAN MEET TODAY'S GRAND CHALLENGES AND BE PREPARED FOR TOMORROW'S. OUR CONTINUED ECONOMIC GROWTH DEPENDS ON IT.

Mr. **Brown**. Without objection, so ordered.

I don't see Mr. Lewis here at this point. We will move on to Mr. Boucher for his comments.

Mr. **Boucher**. Thank you very much, Mr. Chairman. I am pleased to report on the activities of the Science Subcommittee with respect to H.R. 656, and amendments in the nature of a substitute for the original legislation was considered by the subcommittee, approved and ordered reported. In developing that substitute, we worked very closely with Mr. Valentine, Mr. Lewis and others of our colleagues on the subcommittee on Technology and Competitiveness. I would like to take this opportunity to thank them for their able assistance.

We also worked actively with the ranking Republican member of the full committee, Mr. Walker, and I extend my thanks to him for his help in structuring the substitute which is before the committee today. The substitute incorporated all the amendments to H.R. 656 which were approved by the Subcommittee on Technology and Competitiveness at its markup on April 10.

High performance computing has emerged as a very powerful tool in both science and engineering research, in product and processes development, and indeed in all processes of manufacturing. Computers can be used to create elaborate models of natural process that in turn can be used to fast- forward climate, zoom in on molecules, or slow down the physics of subatomic particles.

But to fully utilize the capabilities of high performance computing, we need the existence of a high capacity national data network. Such a network will bring every scientist and engineer as close as his personal computer to collaborations with colleagues across the country, to access to central facilities such as supercomputers, and to access to specialized data networks.

Although a great deal of progress has heretofore been made in high performance computing, a broad consensus has now emerged that the time is ripe for a national effort such as that proposed by H.R. 656. The bill authorizes funding for the development and use of new supercomputers, advanced software, and a national research and education network.

Support is also provided for basic research and the extension of the human resource base in computer and computational sciences.

Mr. Chairman, I want to thank you for your leadership in introducing H.R. 656 and in moving the legislation forward. I particularly want to acknowledge the able assistance of the ranking minority member of the Science Subcommittee, the gentleman from California, Mr. Packard.

Mr. Chairman, with that said, and again in recognition of the Chairman's desire for brevity, I will simply ask unanimous consent that the balance of this statement be submitted for the record, and will commend the legislation to the full committee's consideration.

[The prepared statement of Mr. Boucher follows:]

STATEMENT OF
THE HONORABLE RICK BOUCHER (D-VA)
CHAIRMAN, SUBCOMMITTEE ON SCIENCE
ON
FULL COMMITTEE MARKUP OF H.R. 656, THE HIGH PERFORMANCE COMPUTING ACT OF 1991

MAY 8, 1991

On April 17 the Subcommittee on Science marked up H.R. 656. An amendment in the nature of a substitute was approved and ordered reported.

In developing the substitute, we worked closely with the Subcommittee on Technology and Competitiveness, which had joint referral of H.R. 656, and with the Republican leadership of the subcommittees and the Ranking Republican Member of the Full Committee. The substitute incorporated all of the amendments to H.R. 656 approved by the Technology and Competitiveness Subcommittee at its markup on April 10th.

High-performance computing has emerged as a powerful tool in science and engineering research, in product and process development, and in all aspects of manufacturing. Computers can be used to create elaborate models of natural processes that in turn can be used to fast-forward climate, zoom-in on molecules, *or slow down the physics of subatomic particles.*

But to fully utilize the full power of high-performance computing requires the existence of a high-capacity national data network. Such a network will bring every scientist and engineer as close as his personal computer to collaborations with colleagues across the country, to access to central facilities, such as supercomputers, and to access to specialized data bases.

Although much progress has been made in high-performance computing, a broad consensus has emerged that the time is ripe for a broad national effort. That is what our legislation proposes. The bill authorizes funding for the development and use of new supercomputers, advanced software, and a National Research and Education Network, capable of transmitting billions of bits of data per second. Support is also provided for basic research and the expansion of the human resource base in computer and computational sciences.

The amendment authorizes a total of $1.55 billion for the NSF, $609 million for NASA, $666 million for DOE, $38 million for the Department of Commerce, and $30 million for EPA for *fiscal years 1992-1996. These authorizations are from sums otherwise authorized to the agencies through the usual authorization process. Each agency participating in the program is required by the legislation to include a specific funding request for the program in its annual budget submission.*

Mr. Chairman, I want to thank you for your leadership in introducing H.R. 656 and in moving the legislation forward. Also, I want to recognize the efforts of Mr. Packard, the Ranking Republican Member of the Science Subcommittee, and our colleagues on the Technology and Competitiveness Subcommittee.

Mr. **Brown**. Without objection, so ordered. Now we will hear from Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman. I will again be brief. I support this amendment in the nature of a substitute. The substitute is the product of negotiations among the minority, the majority, and the Administration. We feel—I certainly feel—it is a well-balanced bill that reflects the concerns of many of the different interests that are affected by it.

It provides for a coordinated Federal research program, which is to be a commercial venture from the very beginning. Cooperative interagency initiatives will spur progress and innovation in high performance computing which has proven to be a powerful tool in the manufacturing process, product development and science research. The potential applications of high performance computing will undoubtedly enhance this Nation's international competitiveness.

I also support the bill because the amounts to be authorized for the agencies are in accordance with the President's request for fiscal year 1992. It is important to realize that the authorizations are from sums otherwise authorized to these agencies through the usual authorizing process. Furthermore, the five-year authorization gives security and continuity to the initiative.

So I wish to certainly lend my support to the substitute. I want to express my appreciation to the subcommittee Chairman and all the members of the subcommittee staff that worked hard to bring this to our full committee markup.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Packard follows:]

STATEMENT OF
THE HONORABLE RON PACKARD (R-CA)
FULL COMMITTEE MARKUP
HIGH PERFORMANCE COMPUTING ACT OF 1991
MAY 8, 1991
2318 RHOB, 10:00 A.M.

THANK YOU MR. CHAIRMAN:

I WOULD LIKE TO EXPRESS MY SUPPORT FOR THE AMENDMENT IN THE NATURE OF A SUBSTITUTE THAT IS BEFORE US TODAY. THIS SUBSTITUTE IS THE PRODUCT OF NEGOTIATIONS AMONG THE MAJORITY, MINORITY, AND THE ADMINISTRATION. I THINK IT IS A WELL-BALANCED BILL THAT REFLECTS THE CONCERNS OF MANY DIFFERENT INTERESTS.

IT PROVIDES FOR A COORDINATED FEDERAL RESEARCH PROGRAM WHICH IS TO BE A COMMERCIAL VENTURE FROM THE VERY BEGINNING. THE COOPERATIVE, INTERAGENCY INITIATIVE WILL SPUR PROGRESS AND INNOVATION IN HIGH-PERFORMANCE COMPUTING WHICH HAS PROVEN TO BE A POWERFUL TOOL IN MANUFACTURING PROCESSES, PRODUCT DEVELOPMENT, AND SCIENTIFIC RESEARCH. THE POTENTIAL APPLICATIONS OF HIGH PERFORMANCE COMPUTING WILL UNDOUBTEDLY ENHANCE THIS NATION'S INTERNATIONAL COMPETITIVENESS.

I ALSO SUPPORT THE BILL BECAUSE THE AMOUNTS AUTHORIZED FOR THE AGENCIES ARE IN ACCORD WITH THE PRESIDENT'S REQUEST FOR FISCAL YEAR 1992. IT IS IMPORTANT TO REALIZE THAT THE AUTHORIZATIONS ARE FROM SUMS OTHERWISE AUTHORIZED TO THESE AGENCIES THROUGH THE USUAL AUTHORIZATION PROCESS. FURTHERMORE, THE FIVE-YEAR AUTHORIZATION GIVES SECURITY AND CONTINUITY TO THE INITIATIVE.

I WOULD LIKE TO THANK THE MEMBERS FROM BOTH OF THE SUBCOMMITTEES AND THE MEMBERS OF THE FULL COMMITTEE FOR THEIR HARD WORK IN GETTING THIS INITIATIVE TO FULL COMMITTEE MARKUP.

Mr. **Brown**. Thank you very much, Mr. Packard. The Chair will recognize any other members who wish to be heard at this point.

[No response.]

Mr. **Brown**. The Chair, since they are all being so responsive to our guidance, will take a moment to comment that this bill is the product of two subcommittees and it demonstrates very, very effectively that two subcommittees can work together constructively and produce a product in a timely fashion. We commend both of the subcommittees for doing that.

I might point out that we probably will be asked for sequential referral to one or more other committees. It is my intention to cooperate fully with other committees who think they have a jurisdictional claim, and by cooperation to ensure their expeditious treatment of this legislation so it can be brought to the floor with—we hope—the full support of all the committees that may have an interest in this particular subject.

We would now recognize Mr. Packard for a motion to adopt the subcommittee report.

Mr. **Packard**. Mr. Chairman, I move that we do adopt the subcommittee report.

Mr. **Brown**. Without objection, the subcommittee report will be adopted. The bill is open for discussion. Does any member wish to be heard on the bill in general before we bring up any amendments?

[No response.]

Mr. **Brown**. If not, does any member have any amendments they wish to be brought forward?

Mr. **Boucher**. Mr. Chairman, I have an amendment at the desk, and would ask unanimous consent that it be considered as read.

Mr. **Brown**. Without objection, that will be the order. The gentleman may explain his amendment.

Mr. **Boucher**. Mr. Chairman, I also ask unanimous consent that the amendment in the nature of a substitute be considered as original text for purposes of the markup.

Mr. **Brown**. Without objection, so ordered.

Mr. **Boucher**. Mr. Chairman, following the markup of H.R. 656 by the Subcommittee on Science, the subcommittee received additional recommendations from the Office on Science and Technology Policy for further refinements to the legislation. The suggestions from OSTP were focused on coordination of the High Performance Computing program and the need to maintain flexibility in various agencies' roles. The substitute, which I am offering at the moment, is a bipartisan measure constructed in collaboration with the minority of both the Science Subcommittee and the Subcommittee on Technology and Competitiveness and the ranking minority member of the full committee. It addresses the concerns that were raised by OSTP. Specifically, it recognizes the past activities of the Federal Coordinating Council for Science, Engineering and Technology in developing a formal plan for the High Performance Computing program. Therefore references in the original bill to developing a plan are deleted in this substitute, and instead emphasis is directed to an annual report to document progress in implementing the program, and to provide updates to the plan as the program evolves.

Requirements for reports other than this new annual report are also deleted.

The subcommittee also transfers explicit responsibility for coordinating implementation of the program by the agencies from the coordinating council to the director of OSTP. And finally, the substitute removes all references to specific coordinating roles of the agencies for various R&D activities within the program.

The substitute does retain the provision assigning the National Science Foundation responsibility for the management of the network subject to policy directions developed through consensus by the agencies that are participating in the program.

Mr. Chairman, I again thank our Republican colleagues for their excellent assistance in constructing this substitute, and I am pleased to commend it for the committee's consideration.

[The amendment offered by Mr. Boucher follows:]

TB1004

AMENDMENT IN THE NATURE OF A SUBSTITUTE TO H.R. 656

BY

Mr. Boucher, Mr. Valentine, Mr. Brown, Mr. Packard, Mr. Lewis and Mr. Walker

Strike all after the enacting clause and insert in lieu thereof the following:

SECTION 1. SHORT TITLE.

This Act may be cited as the ``High-Performance Computing Act of 1991''.

SEC. 2. FINDINGS AND PURPOSE.

(a) FINDINGS.--The Congress finds the following:

(1) Advances in computer science and technology are vital to the Nation's prosperity, national and economic security, and scientific advancement.

(2) The United States currently leads the world in the development and use of high-performance computing for national security, industrial productivity, and science and engineering, but that lead is being challenged by foreign competitors.

(3) Further research and development, expanded educational programs, improved computer research networks, and more effective technology transfer from government to industry are necessary for the United

States to fully reap the benefits of high-performance computing.

(4) Several Federal agencies have ongoing high-performance computing programs, but long-term interagency coordination, cooperation, and planning could enhance the effectiveness of these programs.

(5) A 1989 report entitled ``The Federal High-Performance Computing Program'' and a 1991 report entitled ``Grand Challenges: High-Performance Computing and Communications'' by the Office of Science and Technology Policy outlining a research and development strategy for high-performance computing provides a framework for a multiagency high-performance computing program.

(6) Such a program would provide American researchers and educators with the computer and information resources they need, while demonstrating how advanced computers, high-speed networks, and electronic data bases can improve the national information infrastructure for use by all Americans.

(b) PURPOSE.--It is the purpose of Congress in this Act to help ensure the continued leadership of the United States in high-performance computing and its applications through--

(1) the expansion of Federal support for research, development, and application of high-performance

computing in order to--

(A) establish a high-capacity national research and education computer network;

(B) expand the number of researchers, educators, and students with training in high-performance computing and access to high-performance computing resources;

(C) promote the further development of an information infrastructure of data bases, services, access mechanisms, and research facilities which is available for use through such a national network;

(D) stimulate research on software technology;

(E) promote the more rapid development and wider distribution of computer software tools and applications software;

(F) accelerate the development of high-performance computing systems and subsystems;

(G) ensure that emerging high-performance computing systems and software technologies are available to researchers for the application to Grand Challenges;

(H) promote the inclusion of high-performance computing into educational institutions at all levels;

(I) ensure that appropriate security controls are implemented; and

(J) encourage cooperative programs between industry and high-performance computing centers to enhance industrial competitiveness; and

(2) the improvement of planning and coordination of Federal research and development of high-performance computing.

SEC. 3. DEFINITIONS.

As used in this Act, the term--

(1) ``Director'' means the Director of the Office of Science and Technology Policy;

(2) ``Grand Challenge'' means a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources;

(3) ``high-performance computing systems'' means--

(A) current and new generations of scientific workstations;

(B) vector supercomputer systems;

(C) special purpose and experimental computing systems; and

(D) large scale parallel systems,

developed in the private or public sector; and

(4) ``Network'' means the National Research and Education Network established under section 6.

SEC. 4. MISCELLANEOUS PROVISIONS.

(a) NONAPPLICABILITY.--Except to the extent the appropriate Federal agency or department head determines, the provisions of this Act shall not apply to--

(1) programs or activities regarding computer systems that process classified information; or

(2) computer systems the function, operation, or use of which are those delineated in paragraphs (1) through (5) of section 2315(a) of title 10, United States Code.

(b) ACQUISITION OF PROTOTYPE AND EARLY PRODUCTION MODELS.--As part of the Program described in section 5, and in accordance with Federal contracting law, Federal agencies and departments participating in the Program may purchase or lease prototype or early production models of new high-performance computing systems and subsystems to stimulate hardware and software development. Items of computing equipment acquired under this subsection shall be considered research computers for purposes of applicable acquisition regulations.

SEC. 5. NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM.

(a) NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM.--(1) The President shall implement a National High-Performance Computing Program (hereafter in this Act referred to as the ``Program'').

(2) The Director shall--

(A) submit to the Congress an annual report, along with the President's annual budget request, describing the implementation of the Program;

(B) provide for interagency coordination of the implementation of the Program;

(C) review, prior to the President's submission to the Congress of the annual budget estimate, each agency and departmental budget estimate in the context of the Program and make the results of that review available to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget; and

(D) consult with academic, State, industry, and other appropriate groups conducting research on and using high-performance computing.

(3) The annual report submitted under paragraph (2)(A) shall--

(A) describe the goals and priorities for the Program;

(B) set forth the relevant programs and activities, for the fiscal year with respect to which the budget submission applies, of each Federal agency and department, including--

(i) the National Science Foundation;

(ii) the Department of Commerce, particularly the

National Institute of Standards and Technology, and the National Oceanic and Atmospheric Administration;

(iii) the National Aeronautics and Space Administration;

(iv) the Department of Defense, particularly the Defense Advanced Research Projects Agency;

(v) the Department of Energy;

(vi) the Department of Health and Human Services, particularly the National Institutes of Health and the National Library of Medicine;

(vii) the Environmental Protection Agency; and

(viii) such other agencies and departments as the President or the Director considers appropriate;

(C) describe the levels of Federal funding for the fiscal year during which such report is submitted, and the levels proposed for the fiscal year with respect to which the budget submission applies, for specific activities, including education, research activities, hardware and software development, and support for the establishment of the Network;

(D) describe the levels of Federal funding for each agency and department participating in the Program for the fiscal year during which such report is submitted, and the levels proposed for the fiscal year with respect to which the budget submission applies; and

(E) include an analysis of the progress made toward achieving the goals and priorities established for the Program.

(4) The Program shall address the security requirements, policies, and standards issued by the Secretary of Commerce necessary to protect national research computer networks and information resources accessible through national research computer networks, including research required to establish security standards for high-performance computing systems and networks. Agencies and departments identified in the annual report submitted under paragraph (2)(A) shall define and implement a security plan consistent with the Program and with applicable law.

(5) The Program shall--

(A) provide for the establishment of policies for management and access to the Network;

(B) provide for oversight of the operation and evolution of the Network; and

(C) ensure the connectivity among computer networks of Federal agencies and departments.

(b) HIGH-PERFORMANCE COMPUTING ADVISORY PANEL.--The Director shall establish a High-Performance Computing Advisory Panel consisting of non-Federal members, including representatives of the research, education, and library communities, network providers, and industry, who are specially qualified to provide the Director with advice and information on high-performance computing. The Director shall consider the recommendations of the Panel in reviewing and revising the Program. The Panel shall provide the Director with an independent assessment of--

(1) progress made in implementing the Program;

(2) the need to revise the Program;

(3) the balance between the components of the Program;

(4) whether the research and development funded under the Program is helping to maintain United States leadership in computing technology; and

(5) other issues identified by the Director.

(d) OFFICE OF MANAGEMENT AND BUDGET.--(1) Each appropriate Federal agency and department involved in high-performance computing shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report to the Office identifying each element of its high-performance computing activities, which--

(A) specifies whether each such element (i) contributes primarily to the implementation of the Program, or (ii) contributes primarily to the achievement of other objectives but aids Program implementation in important ways; and

(B) states the portion of its request for appropriations that is allocated to each such element.

(2) The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency and departmental responsibilities set forth in the annual report submitted under subsection (a)(2)(A), and shall include, in the President's annual budget estimate, a statement of the portion of each appropriate agency or department's annual budget estimate that is allocated to each element of such agency or department's high-performance computing activities.

SEC. 6. NATIONAL RESEARCH AND EDUCATION NETWORK.

(a) ESTABLISHMENT.--As part of the Program described in section 5, the Director shall coordinate implementation of agency and department activities supporting the broad deployment and use of a national multi-gigabit-per-second research and education computer network, to be known as the National Research and Education Network, which shall link research institutions and educational institutions, government, and industry in every State. For purposes of this section, agency activities may include research and development, development of network applications important for research and education, and contracting for services, but shall not include purchasing switches, optical fiber, or any other networking hardware for purposes other than research and development.

(b) ACCESS.--Federal agencies shall work with State and local agencies, libraries, educational institutions and organizations, and private network service providers as appropriate in order to ensure that the researchers, educators, and students have access to the Network. The Network shall provide users with appropriate access to high-performance computing systems, computer data bases, other research facilities, and libraries. The Network shall provide access, to the extent practicable, to electronic information resources maintained by libraries, research facilities, publishers, and affiliated organizations.

(c) NETWORK CHARACTERISTICS.--The Network shall--

(1) be developed jointly with the computer, telecommunications, and information industries;

(2) be designed, developed, and operated in collaboration with potential users in government, industry, and research institutions and educational institutions;

(3) be designed, developed, and operated in a manner which fosters and maintains competition and private sector investment in high speed data networking within the telecommunications industry;

(4) be designed, developed, and operated in a manner which promotes research and development leading to deployment of commercial data communications and telecommunications standards, for such purposes as

encouraging the establishment of privately operated high-speed commercial networks;

(5) be designed to ensure the continued application of laws that provide network and information resources security measures that protect copyright and intellectual property rights, or that control access to data bases;

(6) have accounting mechanisms which allow users or groups of users to be charged for their usage of copyrighted materials available over the Network and, where appropriate and technically feasible, for their usage of the Network;

(7) ensure the interoperability of agency and department networks and regional private networks;

(8) be developed by purchasing standard commercial transmission and network services from vendors whenever feasible;

(9) be developed by obtaining customized network services from vendors when it is not feasible to obtain standard services or no such standard services are available; and

(10) support research and development of networking software and hardware.

(d) NATIONAL SCIENCE FOUNDATION RESPONSIBILITY.--Within the Federal Government, the National Science Foundation shall be responsible for managing the Network according to policies established for the Program under section 5(a)(5)(A).

(e) INFORMATION SERVICES.--The Director shall coordinate implementation of the activities of appropriate agencies and departments to promote the development of information services that could be provided over the Network. These services may include the provision of directories of users and services on computer networks, data bases of unclassified Federal scientific data, training of users of data bases and networks, access to commercial information services for users of the Network, and technology to support computer-based collaboration that allows researchers around the Nation to share information and instrumentation.

(f) USE OF GRANT FUNDS.--The National Science Foundation, the National Aeronautics and Space Administration, the Department of Energy, the Department of Defense, the Department of Commerce, the Department of the Interior, the Department of Agriculture, the Department of Health and Human Services, and the Environmental Protection Agency may allow recipients of Federal research grants to use grant funds to pay for computer networking expenses associated with the Program.

SEC. 7. ROLE OF THE NATIONAL SCIENCE FOUNDATION.

(a) GENERAL RESPONSIBILITIES.--As part of the Program described in section 5, the National Science Foundation shall provide computing and networking infrastructure support for all science and engineering disciplines, and support basic research and human resource development in all aspects of high-performance computing and advanced high-speed computer networking.

(b) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the National Science Foundation for the purposes of this Act $213,000,000 for fiscal year 1992; $262,000,000 for fiscal year 1993; $305,000,000 for fiscal year 1994; $354,000,000 for fiscal year 1995; and $413,000,000 for fiscal year 1996.

SEC. 8. ROLE OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

(a) GENERAL RESPONSIBILITIES.--As part of the Program described in section 5, the National Aeronautics and Space Administration shall conduct basic and applied research in high-performance computing, particularly in the fields of computational aerosciences, earth and space sciences, and remote exploration and experimentation.

(b) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the National Aeronautics and Space Administration for the purposes of this Act $72,000,000 for fiscal year 1992; $107,000,000 for fiscal year 1993; $134,000,000 for fiscal year 1994; $151,000,000 for fiscal year 1995; and $145,000,000 for fiscal year 1996.

SEC. 9. ROLE OF THE DEPARTMENT OF ENERGY.

(a) GENERAL RESPONSIBILITIES.--As part of the Program described in section 5, the Department of Energy shall--

(1) perform technology development and systems evaluation of high-performance computing systems;

(2) conduct computational research with emphasis on energy applications;

(3) conduct gigabit network applications research and develop related software tools; and

(4) support basic research and human resource development in computational science.

(b) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the Department of Energy for the purposes of this Act $93,000,000 for fiscal year 1992; $110,000,000 for fiscal year 1993; $138,000,000 for fiscal year 1994; $157,000,000 for fiscal year 1995; and $168,000,000 for fiscal year 1996.

SEC. 10. ROLE OF THE DEPARTMENT OF COMMERCE.

(a) GENERAL RESPONSIBILITIES.--As part of the Program described in section 5--

(1) the National Institute of Standards and Technology shall conduct basic and applied measurement research needed to support various high-performance

computing systems and networks, and, in consultation with other relevant agencies and private industry, may adopt standards and guidelines, and develop measurement techniques and test methods, for the interoperability of high-performance computing systems in networks and for common user interfaces to systems, and shall be responsible for developing benchmark tests and standards for high-performance computing systems and software; and

(2) the National Oceanic and Atmospheric Administration shall conduct basic and applied research in weather prediction and ocean sciences, particularly in development of new forecast models, in computational fluid dynamics, and in the incorporation of evolving computer architectures and networks into the systems that carry out agency missions.

(b) HIGH-PERFORMANCE COMPUTING AND NETWORK SECURITY.--The National Institute of Standards and Technology shall conduct research needed to support the adoption of security standards for high-performance computing systems and networks. In accomplishing this objective, the National Institute of Standards and Technology shall utilize whenever possible recognized centers of expertise that may exist in the academic and national laboratory communities.

(c) STUDY OF IMPACT OF REGULATIONS.--(1) The Secretary of Commerce, in consultation with the Administrator of the

Office of Federal Procurement Policy, shall conduct a study to evaluate the impact of Federal procurement regulations which require that contractors providing software to the Federal Government share the rights to proprietary software development tools that the contractors use to develop the software, including a determination of whether such regulations discourage development of improved software development tools and techniques.

(2) The Secretary of Commerce shall, within 1 year after the date of enactment of this Act, report to the Congress regarding the results of the study conducted under paragraph (1).

(d) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated--

(1) to the National Institute of Standards and Technology for the purposes of this Act $3,000,000 for fiscal year 1992; $3,500,000 for fiscal year 1993; $4,000,000 for fiscal year 1994; $4,500,000 for fiscal year 1995; and $5,000,000 for fiscal year 1996.

(2) to the National Oceanic and Atmospheric Administration for the purposes of this Act $2,500,000 for fiscal year 1992; $3,000,000 for fiscal year 1993; $3,500,000 for fiscal year 1994; $4,000,000 for fiscal year 1995; and $4,500,000 for fiscal year 1996..

SEC. 11. ROLE OF THE ENVIRONMENTAL PROTECTION AGENCY.

(a) GENERAL RESPONSIBILITIES.--As part of the Program described in section 5, the Environmental Protection Agency shall conduct basic and applied research directed toward the advancement and dissemination of computational techniques and software tools which form the core of ecosystem, atmospheric chemistry, and atmospheric dynamics models.

(b) AUTHORIZATION OF APPROPRIATIONS.--From sums otherwise authorized to be appropriated, there are authorized to be appropriated to the Environmental Protection Agency for the purposes of this Act $5,000,000 for fiscal year 1992; $5,500,000 for fiscal year 1993; $6,000,000 for fiscal year 1994; $6,500,000 for fiscal year 1995; and $7,000,000 for fiscal year 1996.

Mr. **Brown**. You have heard the description of the substitute. Is there further discussion?

[No response.]

Mr. **Brown**. Do you move the adoption of the substitute, Mr. Boucher?

Mr. **Boucher**. I do, Mr. Chairman.

Mr. **Brown**. It has been moved and seconded and the Chair will put the question. All those in favor signify by saying aye.

[Chorus of ayes.]

Mr. **Brown**. Opposed, no.

[No response.]

Mr. **Brown**. The substitute is adopted. The Chair believes we are ready for a motion to report the bill.

Mr. **Walker**. Mr. Chairman, I move that the committee report the bill, H.R. 656, as amended, and to instruct the staff to prepare the legislative report and make the technical and conforming amendments and that the Chairman take all necessary steps to bring the bill before the House for consideration.

Mr. **Brown**. You have heard the motion. Any debate?

If not, the Chair will put the question. All those in favor of the motion, signify by saying aye.

[Chorus of ayes.]

Mr. **Brown**. Opposed, no.

[No response.]

Mr. **Brown**. The ayes have it. The bill is reported.

[The prepared statements of Messers. Mineta, Lewis, and McMillen follow:]

MAY 8, 1991
NORMAN Y. MINETA, M.C.

NORMAN Y. MINETA, M.C.

MR. CHAIRMAN, I CONGRATULATE YOU ON HOLDING THIS MARK-UP TODAY AND FOR YOUR HARD WORK ON MOVING THESE BILLS TO FULL COMMITTEE.

MR. CHAIRMAN, I WOULD LIKE TO ADDRESS MY OPENING REMARKS TO ONE BILL IN PARTICULAR THAT THE COMMITTEE WILL MARK UP TODAY: H.R. 656, THE HIGH PERFORMANCE COMPUTING ACT OF 1991.

MR. CHAIRMAN, IN THE 1990S AND BEYOND, THE CLEAR CHALLENGE FACING THE UNITED STATES IS TO CREATE AN ENVIRONMENT THAT WILL FOSTER AND SUPPORT OUR ECONOMIC STRENGTH AT HOME, AND COMPETITIVENESS ABROAD.

For too long, we have failed to coordinate the efforts of Federal Agencies, Universities, National Laboratories, researchers, and educators. For too long we have ignored the importance of information sharing, and have failed to develop our information infrastructure of data bases, services, access mechanisms, and research facilities.

For America to regain its economic superiority, we must get more competitive. The High Performance Computing Act is a vital part of the competitiveness solution.

Simply put, our competitiveness depends on the ability of the Federal government to coordinate its efforts and make technology information more accessible to every public private community that can benefit from this information infrastructure.

Mr. Chairman, the High Performance Computing Act of 1991 is critical part of this coordinated effort.

Thank you.

OPENING STATEMENT
HON. TOM LEWIS (R-FL)
HIGH-PERFORMANCE COMPUTING ACT, H.R. 656
MAY 8, 1991

Thank you Mr. Chairman.

The Technology and Competitiveness Subcommittee marked up the High-Performance Computing Act, H.R. 656, April 10, 1991. The legislation was bipartisan and passed unanimously. Since that time, it has undergone numerous changes, and, in may opinion, has been improved significantly.

On April 25, 1991, the Office of Science and Technology Policy released a report on 22 critical technologies. One of those, which is no surprise, was high-performance computing.

The OSTP report states, "...the United States no longer has a clear lead in non-defense supercomputing applications, and competition in the development of supercomputing systems is growing rapidly."

Mr. Chairman, this legislation before the Committee is a step in the direction of ensuring that we develop the computer technology to meet the competition from other nations.

I want to thank Subcommittee Chairman Valentine, Chairman Brown and Ranking Member walker for their hard work and leadership in moving this important legislation so quickly.

I urge my colleagues support of the High-Performance Computing Act of 1991, H.R. 656, as amended.

Thank you Mr. Chairman.

STATEMENT OF REP TOM MCMILLEN -- MARKUP MAY 8 1991

MR CHAIRMAN, ONCE AGAIN CONGRATULATIONS FOR EXPEDITIOUSLY BRINGING TO OUR ATTENTION THESE 3 BILLS THAT WE HAVE BEFORE US TODAY. I LOOK FORWARD TO A CONSTRUCTIVE MARKUP, BUT BEFORE WE BEGIN I WOULD LIKE TO OFFER SOME COMMENTS.

I AM PARTICULARLY PLEASED THAT TODAY'S MARKUP INCLUDES HR 656, A BILL TO REINFORCE OUR NATION'S RESEARCH CAPABILITY IN THE SUPER, HIGH CAPACITY COMPUTING SCIENCES. THESE COMPUTERS WILL ALLOW US TO MOVE TO NEXT LEVEL OF INFORMATION PROCESSING -- A LEVEL THAT WE MUST ATTAIN IF WE ARE TO MAKE ADVANCEMENTS IN MANY OF THE BASIC AND APPLIED SCIENCES. COMPUTERS WITH ULTRA LARGE MEMORY CAPACITIES ARE CRITICAL IN THE STUDY OF PHYSICS, ESPECIALLY AS IT RELATES TO MILITARY HARDWARE APPLICATIONS. I KNOW THAT THE DARPA SUPER COMPUTER SYSTEM, LOCATED AT THE UNIV. OF MARYLAND SCIENCE AND TECHNOLOGY CENTER IN BOWIE MARYLAND, WILL BENEFIT FROM FUNDS AUTHORIZED IN THIS BILL. THEIR MILITARY SCIENCE AND CRYPTOGRAPHY PROJECTS DEPEND ON COMPUTERS THAT ARE STATE OF THE ART, CAPABLE OF EXECUTING MODELLING PROJECTS USING HUGE QUANTITIES OF DATA. THIS COMPUTER IS OF VITAL IMPORTANCE TO THE NATIONAL SECURITY AGENCY -

NSA. THEY USE THE SUPER COMPUTER TO ASSIST THEM WITH THE TECHNICAL ASPECTS OF THEIR INTELLIGENCE AND SECURITY WORK.

SAME WE NOW HAVE TO PUT IN PLACE THE KIND OF COMPUTER RESEARCH EFFORT THAT WILL PERMIT US TO REACH THAT NEXT LEVEL OF TECHNICAL SOPHISTICATION. I APPLAUD THE EFFORTS OF MR BOUCHER AND MR BROWN IN BRINGING THIS BILL FORWARD. THANK YOU.